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OF THE

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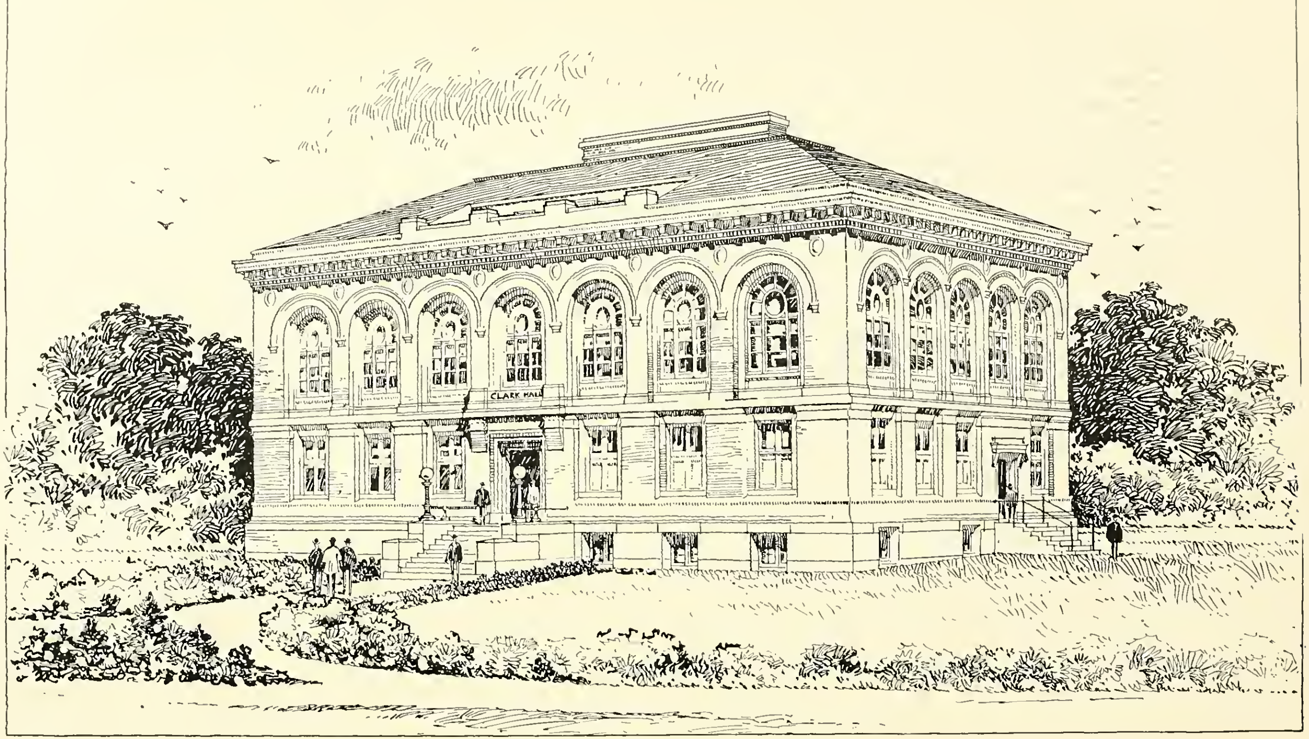

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1906.

To His Excellency CURTIS GUILD, Jr.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the forty-fourth annual report of the trustees of the Massachusetts Agricultural College, for the fiscal year ended Nov. 30, 1906.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

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CALENDAR FOR 1907-1908.

Jan. 2, 1907, Wednesday, fall semester resumed, at 8 A M.

February 6, Wednesday, fall semester ends.

February 7, Thursday, spring semester begins, at 8 A.M.

March 27, Wednesday, to April 3, Wednesday, spring recess.

April 3, Wednesday, spring semester resumed, at 8 A.M.

June 15, Saturday, Grinnell prize examination of the senior class in agriculture.

June 16, Sunday, Baccalaureate address.

June 17, Monday, Burnham prize speaking.
Flint prize oratorical contest.

June 18, Tuesday, Class-day exercises.
Meeting of the alumni.
Reception by the president and trustees.

June 19, Wednesday, commencement exercises.

June 20, 21, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Pittsfield; and at Horticultural Hall, Worcester.

September 17, 18, Tuesday and Wednesday, examinations for admission, at 9 A M., Botanic Museum.

September 19, Thursday, fall semester begins, at 8 A.M.

December 19, Thursday, to Jan. 2, 1908, Thursday, winter recess.

January 2, Thursday, fall semester resumed, at 8 A.M.

February 5, Wednesday, fall semester ends.

February 6, Thursday, spring semester begins, at 8 A.M.

March 26, Thursday, to April 2, Thursday, spring recess.

April 2, Thursday, spring semester resumed, at 8 A.M.

June 17, Wednesday, commencement exercises.

Report of the President of the College.

Gentlemen of the Corporation of the Massachusetts Agricultural College.

In presenting my first report as president of the college, I shall content myself with a very brief survey of the work of the year. The term of Prof. William P. Brooks, as acting president, expired June 30. I am indebted to him for the data on which the report for the first part of the year is based.

In this connection I desire to express formally my personal appreciation of the services of Professor Brooks as acting president. He occupied with great credit a difficult office. No one can appreciate this more fully than he who comes to an institution at a time when a considerable interim has been filled by an acting president. Such a man will find himself either seriously handicapped or wonderfully assisted by the way in which the acting president has carried on the task. With this fact in mind, I desire to give cordial recognition to Professor Brooks's work, and to his courtesy to me personally at the time of my assuming the office of president.

Changes in the Faculty.

Early in the year the resignation of Dr. Charles S. Walker, who was on leave of absence during the year, was received and accepted by the trustees. Dr. Walker had served as professor of political science and as chaplain since 1886, and for part of that period was secretary of the faculty. He was a forceful writer on themes connected with his favorite subjects. He had long had a special interest in the development of the agricultural phases of economics.

Dr. Richard S. Lull, associate professor of zoölogy, resigned at the end of the college year, to accept an unusually

flattering position in Yale University. Dr. Lull had been connected with the college since 1894, and was recognized as a teacher of exceptional power. The position thus made vacant was filled by the appointment of Clarence E. Gordon, A.M. Professor Gordon is a graduate of the Massachusetts Agricultural College in the class of 1901, and secured his Master's Degree at Columbia University.

The trustees also accepted the resignation of Prof. Herman Babson, assistant professor of English and instructor in German. Professor Babson resigned in order to pursue his studies in the German language and literature abroad. He had served the college since 1893. His place was filled by the appointment of Robert W. Neal, A.M., a graduate of the University of Kansas. Professor Neal has done advanced work in both Yale and Harvard, and has the degree of A.M. from the latter institution; he has also had successful and important editorial experience.

During the last college year instruction in history was carried on most acceptably by Prof. Herbert P. Gallinger of Amherst College. This year Mr. Holcomb was given, in addition to his other duties, the position of instructor in history.

Maurice A. Blake resigned as instructor in horticulture, to accept the position of horticulturist of the New Jersey Experiment Station, and severed his connection with the college November 30. Mr. Blake had served with great credit as instructor, and had been particularly useful in the practical work of the department.

The State Forester of Massachusetts is also lecturer in forestry in this college. Mr. Alfred Akerman resigned this office last summer, and has been succeeded by Prof. F. William Rane, who has been for eleven years professor of horticulture and forestry at the New Hampshire College of Agriculture and Mechanic Arts.

Mr. C. P. Halligan takes the position of instructor in drawing, made vacant by the resignation of Mr. Walter D. Hatch.

Miss Gertrude E. Stratton, secretary to the president, resigned during the summer, after a constant service of some

eighteen years, and the vacancy was filled by the appointment of Miss Grace M. Knowles, a graduate of the private secretarial course of Simmons College in the class of 1906.

Attendance.

The total attendance for the college year ended June 30, 1906, was as follows: —

Graduate students,	7	
Special students,	1	
Senior students,	27	
Junior class,	28	
Sophomore class,	61	
Freshman class,	90	
Short course, 1905,	41	
		255
Counted twice,		1
Total,		254

This shows an increase in total registration over the previous college year of 28. The registration Nov. 30, 1906, is 225, as compared with 214 at the same date a year ago.

Director of the Experiment Station.

By vote of the trustees, the office of the director of the experiment station was separated from that of the president of the college, and Prof. William P. Brooks was made director of the station, in which capacity he had already been serving while acting president of the college. Professor Brooks brings to this work long years of preparation and service, and an intimate acquaintance, not only with experimental work, but with the needs of Massachusetts agriculture.

Appropriations.

The last Legislature was asked to make appropriations as follows: —

New building and plant house for the botanical department,	$75,000
New greenhouse for the horticultural department,	20,000
Duplicate engine and generator for lighting plant,	5,000
Maintenance and repairs,	4,500
Barn, stables, piggery, silos and farm dairy building,	63,000
For maintenance of the horticultural building, annually,	1,000

The items completely cut out were the new greenhouse, duplicate engine and generator, and maintenance of the horticultural building. The appropriation for the botanical building was not made sufficiently large to cover a plant house nor to provide for equipment. The appropriation for the barn, stables, etc., was largely reduced. The appropriation for maintenance and repairs was increased $500.

The Legislature made extraordinary appropriations amounting to $75,300, as follows: —

For Clark Hall,	$45,000
For barns and silos,	21,300
For farm dairy building,	3,000
For piggery,	1,000
For repairs,	3,000
For maintenance,	2,000

In addition to legislative provision for barns and silos, about $12,000 of the total of about $17,300 received for insurance was made available by vote of the trustees.

New Buildings.

The destruction of the dairy building by fire in November made necessary some provisions for the practical work of the short course in dairy farming. Rooms formerly used for heating apparatus and cold storage in the basement of south college were fitted for this purpose, and equipped with a very complete line of dairy machinery. The number of students enrolled for the dairy course was 29, — a smaller number than in recent years. Some students, as was learned later, decided on going elsewhere, on seeing the newspaper reports of the destruction of the old dairy building.

Wilder Hall was completed early in the year, and occupied at the beginning of the second semester.

The new barn, with attached silos, stables and milk room, is nearing completion. The same is true of the new building for the department of botany and vegetable pathology. The latter building has been named "Clark Hall," in honor of William S. Clark, president of the college from 1867 to 1879. A brief description of this structure, together with the plan of the architects, will accompany this report.

Master's Degree.

A change was made in the conditions under which graduate study for the degree of Master of Science may be carried on. This change will permit graduates of the Massachusetts Agricultural College, or other approved institutions, who may be employed in the college or the experiment station, to pursue studies for a degree in connection with any work done in discharge of the duties held which has a recognized value in fitting a man for the degree, and may be counted as a part of the work for the degree.

Annual Commencement.

At the annual commencement, held June 20, 27 persons received the degree of Bachelor of Science, and 1 the degree of Master of Science. The address of the day was given by Prof. L. H. Bailey, dean of the College of Agriculture of Cornell University. The subject was "Leadership in Country Life." It was an inspiring presentation of the opportunities now arising for educated young men to be of effective service in the country community.

"Better Farming Special" Train.

One event of the past year deserving of especial mention was the equipment and manning of a "Better Farming Special" train, — the first of its kind in New England. This train, consisting of an engine, a baggage car and three passenger coaches, was furnished, entirely without charge either for rolling stock, train crew or operation, by the Boston & Maine Railroad. The material which was used in furnishing the train was jointly supplied by the agricultural colleges and experiment stations of New Hampshire, Vermont and Massachusetts, and the train passed over a considerable proportion of the lines of the Boston & Maine Railroad system in these States, beginning in Massachusetts on Tuesday, April 3, in Amherst, and ending in this State on Saturday, April 7, in Haverhill. As the trip was to be begun in Massachusetts, and as the trolley line extension into the college grounds connecting with the Boston & Maine Railroad afforded such ad-

vantages for the work, the cars were fitted and equipped for their trip in Amherst. The general expenses incurred in preparing the train were shared equally by the three States above mentioned.

The baggage car was fitted with special benches, and was used largely for the display of material of interest in connection with forestry and orcharding. It also contained a case of general views of the Massachusetts Agricultural College. The plan followed in the passenger cars was first to remove about one-third of the seats in each car. The space thus cleared was furnished with benches and shelves, the benches, the shelves and the walls being used for the display of the illustrative material. The exhibits were classified, those in one car being designed to illustrate especially some of the problems connected with the selection and use of fertilizers and the general management of farm crops. The material in the second car was illustrative of animal husbandry and dairying. In the third passenger coach the material was selected with reference to illustrating some of the subjects in horticulture and the insect pests of the farm. Each of the four cars bore a banner on either side, extending the full length of the car. The first, attached to the baggage car, bore the words "Better Farming Special." The passenger coaches were marked, respectively: "Farm Crops and Fertilizers;" "Animal Husbandry and Dairying;" "Horticulture and Insect Pests."

A careful schedule had been planned beforehand, and had been given wide publicity, chiefly through the agency of the "New England Homestead." The time of arrival and departure from each station had been extensively advertised, and at every station a goodly number of people was in waiting. The places at which stops were made and talks given in Massachusetts were the following: Amherst, Mt. Hermon, Bernardston, Greenfield, South Deerfield, Hatfield, Northampton, Hadley, Belchertown, Barre Plains, Rutland, Hubbardston, Gardner, Fitchburg, North Leominster, Ayer, Lancaster, Hudson, Wayland, Weston, Wakefield, Reading, Tewksbury, Andover, Georgetown and Haverhill.

The stops at stations averaged about fifty minutes each,

and the schedule as planned was carried out almost to the minute.

The speakers in Massachusetts were mainly from the college and station; but the college staff was ably assisted by A. D. Shamel, the tobacco expert of the United States Department of Agriculture, in towns where tobacco growing was of importance; by E. A. Start, secretary of the Massachusetts Forestry Association; P. M. Harwood, agent of the Dairy Bureau; W. D. Rudd, poultry expert; and S. H. Abbott and W. A. Hunter, of the Co-operative Milk Producers Company; while Secretary Ellsworth of the State Board of Agriculture, who accompanied the train throughout its entire trip in Massachusetts, proved invaluable in making the announcements and handling the crowds in attendance at the different stations.

The following, written shortly after the trip in Massachusetts was completed, and published in the "Homestead," is of interest: —

The smallest number of visitors at any station was 150 to 175. As many as 700 visited the train in some places, and the average number at the different stations was probably 350 to 400. The quality of the visitors was equally as satisfactory as the numbers. The crowds were composed of the most intelligent and progressive, and included young men, women and children, as well as the older men who so often make up the majority of those in attendance at ordinary farmers' institutes. The attention paid to the short talks and the questions asked made clear the fact that the majority of those in attendance had come to learn. On every hand were constantly heard expressions of approval.

It was estimated that fully 8,000 people in Massachusetts alone inspected the exhibits and listened to the talks. This is a conservative estimate, based upon an actual count from town to town by an editorial representative of the "New England Homestead." The visitors to the train often came from long distances. Incidents were occasionally brought to the notice of those on the train of parties who had driven fourteen or fifteen miles to visit it.

The progress of the train and its work were given the

widest possible publicity by the newspapers. Representatives of a large number of the newspapers of the State accompanied the train, and the accounts published both in city and country papers were full and enthusiastic.

The total cost to the Massachusetts Agricultural College amounted to $246.45. Of this sum, $65.55 was paid to students from the endowed labor fund; the balance, $180.90, was paid in equal parts by the college and the experiment station.

It is believed that the effort and the money expended were well repaid by the results. There can be no doubt that much valuable instruction was conveyed to many interested persons; but in still larger degree the train proved useful in arousing interest in the work of the college and station, and in bringing the people into closer touch with these institutions. Not only must this closer touch and keener appreciation have been felt by the few thousands who actually visited the train, but to no inconsiderable degree also by the many thousands who read the accounts of its progress and its work.

The success of the movement was most gratifying to all concerned, and was due to the heartiest possible co-operation of every one taking a part in the work. To the "New England Homestead" was due in the first place the suggestion, and to the "Homestead" also belongs the credit of having aroused the interest of the Boston & Maine Railroad; and the success of the movement was still further enormously promoted by the widespread publicity given to the movement through the columns of the "Homestead" and the earnest work of members of its editorial staff. The Boston & Maine Railroad also deserves mention. Its generosity and courtesy left nothing to be desired. Everything that could be done to promote the success of the movement on the part of the railroad was done; and it is believed that all who took part in this work, "Homestead" staff, college and station staff, students and railroad, felt that the work had proved its value and had been well worth while.

Commission on New Buildings and Arrangement of Grounds.

The following vote was passed by the trustees at the meeting of Jan. 3, 1905: —

Voted, That a commission, to consist of the committee on new buildings and arrangement of grounds, and two of the faculty to be appointed by that committee, consider the location of future buildings on the grounds of the Massachusetts Agricultural College and all other permanent improvements on the campus, and report to the Board thereon; this commission to be authorized to hold public hearings on the question involved, and so far as they think practicable to ask the advice of experts.

In accordance with this vote, Prof. William P. Brooks and Prof. Frank A. Waugh of the faculty have been added to your standing committee on new buildings and arrangement of grounds, and thus the commission is constituted. I commend this as a most important step in the future development of the college, and trust that this commission may be able to report to your Board in the not distant future a permanent plan for the development of the grounds and for the type and location of buildings which will enable us to proceed systematically and confidently in the evolution of an establishment which shall be, on its material side, an exemplification of all that is artistic and convenient in an institution of this character.

Anniversaries.

In May, 1882, the Legislature passed an act creating the Massachusetts Experiment Station. Massachusetts was one of the leaders of research work in agriculture, and I recommend that some appropriate way be found for celebrating and reviewing the work of the quarter-century.

On Oct. 2, 1907, the college is entitled to celebrate the fortieth anniversary of its opening to students. It is my recommendation, which has been endorsed officially by the faculty of the college and unofficially by numerous alumni, that steps be taken adequately to celebrate this event. The time has arrived when the college should demonstrate its fitness to

become a leader in all forms of rural betterment in Massachusetts, and I can think of no way in which this assumption of leadership can be announced, nor of any way in which the fortieth anniversary of the opening of the college can be celebrated, better than that of holding a "Massachusetts Conference on Rural Progress," at the college, during the week of October 2. The object of this conference should be to bring together, for discussion of all phases of rural betterment in this Commonwealth, representatives of the farmers' organizations and societies, rural educators, rural religious workers and members of village improvement societies. I would recommend that a sufficient sum be set apart to enable us to prepare a strong program, and to bring to our aid speakers of large reputation and of thorough knowledge of the problem.

Department of Agricultural Education.

The Massachusetts Commission on Industrial Education, appointed by Governor Douglas, in the bill which they recommended to the Legislature and which was enacted into law, outlined the following provision, which has become section 7 of the Law: —

Section 7. The trustees of the Massachusetts agricultural college are hereby authorized to establish a normal department for the purpose of giving instruction in the elements of agriculture to persons desiring to teach such elements in the public schools, as provided in sections three and four: *provided,* that the cost of such department shall not exceed the sum of five thousand dollars in any one year, and that at least fifteen candidates present themselves for such instruction.

The money for carrying out this provision of the law was not furnished by the last Legislature, but the sum of $5,000, in accordance with the advice of the State Auditor, has been included in the annual estimate made through that office to the Legislature. It is fortunate that, at the very time when the educational leaders of the State are becoming deeply interested in the development of agricultural teaching in the various grades of schools in the Commonwealth, this college should be recognized as the natural leader in this movement, and given the machinery to make good the leadership.

Extension Teaching.

It is now clearly recognized by agricultural educators that an agricultural college has three distinct functions to perform, each of which is equal in importance to the others, and none of which can safely be neglected.

1. The first business of the college is the work of research. We must find out the truth about nature, — how she works, and how her processes may be utilized by man in the production of plants and animals. This task is at present committed to the agricultural experiment station. It should be the first and sole business of the station.

2. The second great task of the college is to instruct resident students. This is the accepted function of the ordinary college, and in the minds of many is the only function. But the experiment station work is really the college hunting for the truth; the academic work is the college imparting the truth to those who have access to its halls for a period of years.

3. It may be argued that when the college has performed these two functions its mission is fulfilled. But we are coming to see that this is by no means true. The facts obtained and the principles educed by the experiment station are intended not solely for the benefit of the resident students of the college. It is expected that the body of knowledge acquired by the experiment station, and worked over into pedagogical form by the college teachers of agriculture, shall find its way out in free measure to the people who till the soil. The fundamental interests and duties of the college, therefore, lead to the development of its third function, namely, that of extension teaching. The information and the inspiration which are supposed to abide in the atmosphere of the experiment station and the college class room must be taken out to the people. Agriculture progresses not merely through the highly trained expert and the thoroughly educated leader, but ultimately through the increasing knowledge of the working farmer.

This threefold organization of the college is now pretty fully accepted. It is the foundation upon which we must build our work for the future. It is the logical and necessary

basis for that leadership in rural matters which we expect the agricultural college to maintain.

The Massachusetts Agricultural College has from its foundation rendered a large service to the people of the State by means of lectures, correspondence, bulletins, and perhaps in other ways. This work has never been classified. It has always been considered a part of the service of the institution. When we come to analyze it, we discover that it is extension teaching. As I understand it, everybody believes that the college should do this sort of thing. I have never heard the college criticised for doing it. The legitimate question is, whether the college is doing enough of this work; whether it is really reaching the people as it ought to reach them, by the methods that have been in vogue and others that may be organized. I do not think it is. We have done well, but we must do better. But it is clearly out of the question for us to enlarge this work further with our present force. It is undoubtedly desirable for station workers to keep in touch with the farmers and their problems; but, in justice to station work, they can spend very little time in any other way than by direct application to the task in hand. So with the college instructors; they also must keep in the atmosphere of the farmer, but they cannot afford to neglect their duties as teachers. It seems to me, therefore, that the time has arrived when we must organize our extension work, bringing the various forms of it together, placing it under the charge of a competent man, and expanding it as rapidly as the demands for such work develop. There can be no question but the movement for extension teaching in this country is gaining force with great rapidity. Several agricultural colleges have already organized departments of college extension, and others are taking steps towards the same end. Shall Massachusetts be in the van, or shall she lag in the rear?

It may be well to define a little more explicitly what extension work is. The definition of extension work adopted by the committee on extension work of the Association of American Agricultural Colleges and Experiment Stations, is as follows: "Extension teaching in agriculture embraces those forms of instruction, in subjects having to do with

improved methods of agricultural production and with the general welfare of the rural population, that are offered to people not enrolled as resident pupils in educational institutions." Or, as Professor Bailey phrases it: "Extension work comprises all those teaching enterprises that are not of academic kind, and that aim to reach the people and their problems in places where the problems are." An investigation by the above committee reveals an astonishing development of extension work among colleges of agriculture. Without an attempt to go into great detail, we may roughly classify some of these forms of extension teaching. The classification will help illustrate the scope of possible work.

I. *Itinerant Lectures.* — These may embrace such endeavors as: (1) extension lectures to miscellaneous audiences and organizations; (2) courses of extension lectures given to small groups of people who wish to study somewhat carefully; (3) travelling schools, which attempt to give instruction for a considerable period of time to people desiring to specialize, as in fruit, etc.; (4) special railway trains for educational purposes; (5) conferences of teachers, for the purpose of taking up the study of elementary agriculture, etc.; (6) farmers' institutes. In Massachusetts the farmers' institutes are managed by the Board of Agriculture, and we do not need to consider them in connection with this problem, except to suggest that the college should co-operate cordially with the development of institute work.

II. *Literature.* — This embraces: (1) the large correspondence of the station and the college: (2) publication of bulletins, pamphlets, etc., that are not reports of experimentation, but definite statements of agricultural truth, intended to reach the man who wants to have a brief and concise presentation; (3) correspondence courses; (4) reading courses; (5) travelling libraries.

III. *Object Lessons.* — These may comprise: (1) a large number of field demonstrations, given to small audiences, which endeavor to show people just how to perform such operations as may help them in their practical work; (2) co-operative tests and demonstrations which are not so much for the purpose of experimentation as for education; (3)

educational exhibits at fairs, made by the college and station, which are not for advertising, but for educational purposes.

There are other forms of extension teaching that are already being developed, but the above will serve to illustrate what is meant by extension teaching in agriculture, and will show the methods by which an agricultural college may perform its great function of reaching the people, of bearing to them the gospel of better agricultural conditions.

So far as I can see, there are only three legitimate objections to the development of extension teaching at a college like ours; for we can hardly give credence to the idea that the work is not needed or demanded. So far as the need is concerned, I feel quite sure that no one will attempt to argue that even in the most progressive agricultural States there is not need of the most constant vigilance in placing before the working farmers the latest agricultural information. And one of the best evidences of the need of this work is the demand for it on the part of the farmers so soon as they understand what it proposes to do for them.

1. It may of course be argued that this extension teaching is not the function of the agricultural college. It must be remembered that every agricultural college has performed this sort of work for years, not only without criticism, but with cordial approval on the part of the farmer. It is now a generally accepted function of the college to do this; and, indeed, not to do it means shutting up the college for the benefit of the relatively few students who can enroll themselves with it. It means damming up the great fountains of agricultural knowledge, and permitting them to trickle out in faucets reserved for the elect, rather than letting the healing waters flow down through the plains, carrying blessing to the world at large. To prohibit the college from doing extension work means ultimately to stifle the college. The college lives not merely because it teaches students; it lives permanently only as it clasps hands with the farmer himself.

2. It may be objected that this sort of work can better be done by other agencies. It is true that the agricultural college is not the only means by which agricultural knowledge may be disseminated. The agricultural press renders a mar-

vellous service in this capacity. The farmers' institutes, even if not conducted by the college, are great educational institutions, and cannot be dispensed with. The grange, the horticultural societies, the agricultural fairs, the dairy associations and all the host of voluntary organizations, and particularly official bodies like boards of agriculture, have rendered for years and are now rendering a most important service in disseminating agricultural information. The college never can take the place of these agencies, but it can mightily supplement their work. And the reasons why it can and should supplement their work are these: (1) There is an increasing need of expert teachers, who, while keeping close to the practical problems of the farmers, are also constantly studying the new developments of agriculture. To be a successful farmer is only one of many qualifications of a successful teacher of farmers, and the day has arrived when we need experts to give all their time to the work. (2) The experiment station is the great source of new knowledge of agriculture. Our agricultural teachers therefore must be in closest possible touch with the men who are prosecuting agricultural research. Men closely connected with the station have the best opportunities for keeping that touch. (3) But the great reason is that of usefulness. In all the agencies already enumerated, — valuable as they are in giving suggestions, in stimulating the farmers to think, — after all, the work is more or less superficial. Agricultural educators now believe that we are at the dawn of an era in agricultural work when definite, continued, expert instruction of the masses of the people is not only necessary, but feasible. It is clear that the college should not attempt to duplicate or interfere with the work of these other agencies; it should rather build upon their work. It should take the raw materials, so to speak, which they have produced and work them up into finer products. Thus there would be not only no conflict between the extension teaching of the college and the dissemination work performed by other agencies, but the two will happily supplement one another. For ultimately our extension teaching must *teach,* — teach with system and persistency.

3. If the suggestion just made is a pertinent one, it dis-

poses of perhaps the most serious objection to the development of an extension division of the Massachusetts Agricultural College, namely, unnecessary duplication of work. It seems to me that this is a question that can be settled without the slightest friction. It should be understood that the college purposes not to interfere with nor encroach upon the work of the State Grange nor of the Board of Agriculture. Our extension teachers should be placed at the disposal of the Board of Agriculture for farmers' institutes, for demonstration meetings, or for any other work the Board is now doing or may wish to do. We shall expect to co-operate heartily with the grange. I firmly believe that if we go at the matter in this spirit the college can be of great assistance, to the Board of Agriculture particularly. If we secure good extension teachers, they would certainly add to the prestige of the institutes, if the Board chooses to utilize the men for that purpose. Our extension workers may also be able to reach many of the smaller places, many small groups of people, and possibly a great many individuals, that are not now reached and never will be reached by the large institute or field meeting.

There is another consideration that should not be omitted from a discussion of this subject. I am firmly convinced that it is the duty of the Agricultural College, just as soon as it has adequate facilities to do so, to develop much more largely the opportunity which may be given to mature young people through the prosecution of both short winter and summer courses at the college. This work is not true extension teaching, because it is work given to resident students; and yet, because of its character and because of the difficulty of developing it through the regular instructors of the college, already hard pressed for time, I am quite inclined to think that it might well be made a part of our extension work.

As a definite conclusion to this prolonged discussion of extension teaching, I would recommend that the Legislature be asked to appropriate a sum of money sufficient to establish at the Massachusetts Agricultural College a "Division of Extension Teaching;" and that a competent man, with if possible a small corps of assistants, be put in charge of this division.

I have taken pains to elaborate this recommendation, partly because of its great significance in our future policy, and partly also because of the apparent misunderstanding, in some quarters, of the proposal. I feel quite sure that when this plan is once comprehended, not only will it be found unobjectionable, but that it will be welcomed as a great power for good in the building up of a better Massachusetts agriculture. There is no ulterior purpose back of the proposition; it is a frank, open attempt to make our college of larger service. I believe that enlarged extension work at the Massachusetts Agricultural College will not only not weaken the forces of the Board of Agriculture, or of the grange, or of rural societies generally, but, on the contrary, that it will in a few years prove to be the greatest ally which has been brought to their assistance in many a long day. We must not deal with this matter in the light of who shall get the credit for work done; we must keep forever in mind the question, How can the rural people of Massachusetts be given the largest possible assistance?

In view of all the conditions which gather about this proposition, I recommend that your Board appoint a committee of its own members to confer with the executive committee of the State Board of Agriculture, and with the executive committee of the State Grange, in regard to a united effort in behalf of this movement.

Finances.

It is evident that the institution is in need of larger amounts which may be used for maintenance, equipment, and repairs and minor improvements. Estimates covering these items, sent in by the heads of departments, will total some $20,000. It also seems the part of wisdom to ask once more for a new greenhouse. The question of whether we shall ask for an addition to the electric lighting plant will depend very largely upon the success of a possible arrangement for summer and reserve lighting with the Amherst Gas Company. If certain additions to, and increases in the payment of, the faculty and other instructors are made, we shall during the next college year need from $6,000 to $8,000 more than we now have

available for salaries. I have not been able as yet to make a thorough study of the financial needs of the college, but I am convinced that we must soon face the duty of endeavoring to secure a larger current annual appropriation. For the present, I would make the following recommendations with respect to immediate appropriations from the Legislature: —

1. That we ask for a sum sufficient to establish extension teaching; the form of this work and the amount needed I leave to the judgment of your Board.

2. That the following items be incorporated into one bill, as a special appropriation: —

a. For equipping barn, stables and milk room,	$3,000
b. For purchase of live stock for barn,	7,000
c. For equipping and furnishing Clark Hall,	25,000
d. For boiler for heating and lighting plant,	2,000
e. For greenhouse, workrooms and equipment,	22,000
Total,	$59,000

It is also recommended that there be added to this list an item for such an amount as may be determined by your finance committee after a thorough consideration of the reports of the heads of departments, this item to include additional salaries, equipment, maintenance, repairs and minor improvements.

3. That your committee on finance be authorized to study with some care (1) all the financial needs of the college at the present time, (2) such probable demands as will be made upon the college in the near future which must be provided for by increased annual income, and (3) the amount and form which these necessary increases in the budget should take; the committee to make a full report to your Board at a subsequent meeting.

All of which is respectfully submitted.

KENYON L. BUTTERFIELD,
President.

Nov. 30, 1906.

LEGISLATIVE BUDGET.

[As adopted by the committee on finance, Jan. 10, 1907.]

The committee on finance, acting under authority conferred by the Board of Trustees of the college, at a meeting held at the college Jan. 10, 1907, voted to request of the Legislature the following appropriations for the year 1907: —

I. The annual appropriation for instruction ($13,000) to be increased by $7,000 (for miscellaneous salary items), making a total of $20,000 per year.

II. Special appropriations, $73,000.

a. For equipping barn, stables and milk room,	$3,000
b. For purchase of live stock for barn,	7,000
c. For equipping and furnishing Clark Hall,	25,000
d. For boiler for heating and lighting plant,	2,000
e. For greenhouse, workrooms and equipment,	22,000
f. For equipment, maintenance, repairs and minor improvements for the college as a whole and for various departments specifically,	14,000
Total,	$73,000

THE CORPORATION.

	TERM EXPIRES
NATHANIEL I. BOWDITCH of Framingham,	1908
WILLIAM WHEELER of Concord,	1908
ARTHUR G. POLLARD of Lowell,	1909
CHARLES A. GLEASON of New Braintree,	1909
JAMES DRAPER of Worcester,	1910
SAMUEL C. DAMON of Lancaster,	1910
MERRITT I. WHEELER of Great Barrington,	1911
CHARLES H. PRESTON of Danvers,	1911
CARROLL D. WRIGHT of Worcester,	1912
M. FAYETTE DICKINSON of Boston,	1912
WILLIAM H. BOWKER of Boston,	1913
GEORGE H. ELLIS of Boston,	1913
J. HOWE DEMOND of Northampton,	1914
ELMER D. HOWE of Marlborough,	1914

Members ex Officio and Officers.

His Excellency Governor CURTIS GUILD, Jr.,
President of the Corporation.

KENYON L. BUTTERFIELD, *President of the College.*

GEORGE H. MARTIN, *Secretary of the Board of Education.*

J. LEWIS ELLSWORTH, *Secretary of Board of Agriculture.*

CHARLES A. GLEASON of New Braintree,
Vice-President of the Corporation.

J. LEWIS ELLSWORTH of Worcester, *Secretary.*

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Standing Committees of the Trustees.[1]

Committee on Finance.

GEORGE H. ELLIS, J. HOWE DEMOND,
ARTHUR G. POLLARD, CHARLES H. PRESTON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.

WILLIAM H. BOWKER, ELMER D. HOWE,
M. FAYETTE DICKINSON, CARROLL D. WRIGHT,
GEORGE H. MARTIN, WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticulture.

Farm Division.

GEORGE H. ELLIS, CHARLES A. GLEASON,
MERRITT I. WHEELER, N. I. BOWDITCH, *Chairman, and Chm. Joint Committee.*

Horticultural Division.

JAMES DRAPER, ELMER D. HOWE,
J. LEWIS ELLSWORTH, *Chairman.*

Committee on Experiment Department.

J. LEWIS ELLSWORTH, JAMES DRAPER,
WILLIAM H. BOWKER, SAMUEL C. DAMON,
CHARLES H. PRESTON, *Chairman.*

Committee on Buildings and Arrangement of Grounds.

WILLIAM WHEELER, WM. H. BOWKER,
M. FAYETTE DICKINSON, N. I. BOWDITCH,
JAMES DRAPER, *Chairman.*

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[1] The president of the college is *ex officio* member and secretary of standing committees. The director of the experiment station is a member of the committee on experiment department, without vote.

Examining Committee of Overseers.

JOHN BURSLEY (*Chairman*), . . of West Barnstable.
W. C. JEWETT, ... of Worcester.
CHARLES H. SHAYLOR, . . . of Lee.
ISAAC DAMON, ... of Wayland.
A. H. NYE, ... of Blandford.

The Faculty.

KENYON L. BUTTERFIELD, A.M., *President.*

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

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Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

FRANK A. WAUGH, M.S.,
Professor of Horticulture and Landscape Gardening.

GEORGE C. MARTIN, Captain, Eighteenth U. S. Inf.,
Professor of Military Science and Tactics.

PHILIP B. HASBROUCK, B.S.,
Associate Professor of Mathematics.
Adjunct Professor of Physics.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

CLARENCE E. GORDON, A.M.,
Assistant Professor of Zoölogy.

ROBERT W. NEAL, A.M.,
Assistant Professor of English and Instructor in German.

LOUIS R. HERRICK, B.Sc.,
Instructor in French and Spanish.

FRANCIS CANNING,
Instructor in Floriculture.

GEORGE N. HOLCOMB, A.B.,
Instructor in Political Science and History.

A. VINCENT OSMUN, M.Sc.,
Instructor in Botany.

SIDNEY B. HASKELL, B.Sc.,
Instructor in Agriculture.

CHARLES G. BARNUM, A.B.,
Instructor in Chemistry.

MAURICE A. BLAKE, B.Sc.,
Instructor in Horticulture.

HENRY J. FRANKLIN, B.Sc.,
Instructor in Botany.

NATHAN J. HUNTING, B.Sc.,
Instructor in Dairying.

CHARLES P. HALLIGAN, B.Sc.,
Instructor in Drawing.

ERWIN S. FULTON, B.Sc.,
Instructor in Babcock Test.

E. BRINTNALL, B.S.,
Instructor in Butter Making.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law.

FRANK W. RANE, M.S.,
Lecturer on Forestry.

E. FRANCES HALL,
Librarian.

PHILIP B. HASBROUCK, B.S.,
Registrar.

ELWIN H. FORRISTALL, M.Sc.,
Farm Superintendent.

GRACE M. KNOWLES, B.S.,
Secretary to the President.

Graduates of 1906.[1]

Master of Science.

Ballou, Henry Arthur,	St. Michael, Barbadoes.

Bachelor of Science.

Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Craighead, William Hunlie (Boston Univ.),	Boston.
Filer, Harry Burton,	Palmer.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Hall, Jr., Arthur William (Boston Univ.),	North Amherst.
Hastings., Jr., Addison Tyler,	Natick.
Hood, Clarence Ellsworth,	Millis.
Kennedy, Frank Henry,	Ashmont.
Martin, James Edward,	Brockton.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civille (Boston Univ.),	Natick.
Rogers, Stanley Sawyer,	Brookline.
Russell, Harry Merwin,	Bridgeport, Conn.
Scott, Edwin Hobart (Boston Univ.),	Cambridge.
Sleeper, George Warren (Boston Univ.),	Swampscott.
Strain, Benjamin,	Mt. Carmel, Conn.
Suhlke, Herman Augustus,	Leominster.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tirrell, Charles Almon,	Plainfield.
Wellington, Richard,	Waltham.
Wholley, Francis Dallas,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Total,	28

[1] The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1906.

Senior Class.

Alley, Harold Edward, . . .	Gloucester.
Armstrong, Arthur Huguenin, . .	Hyde Park.
Bartlett, Earle Goodman, . . .	Chicago, Ill.
Caruthers, John Thomas, . . .	Columbia, Tenn.
Chace, Wayland Fairbanks, . . .	Middleboro.
Chadwick, Clifton Harland, . .	Cochituate.
Chapman, George Henry, . . .	Wallingford, Conn.
Chapman, Joseph Otis, . . .	East Brewster.
Clark, Jr., Milford Henry, . . .	Sunderland.
Cutter, Frederick Augustus, . .	Lawrence.
Dickinson, Walter Ebenezer, . .	North Amherst.
Eastman, Jasper Fay, ...	Townsend.
Green, Herbert Henry, . . .	Spencer.
Hartford, Archie Augustus, . .	Westford.
Higgins, Arthur William, . . .	Westfield.
King, Clinton, ...	Dorchester.
Larned, Joseph Adelbert, . . .	Amherst.
Lincoln, Ernest Avery, . . .	Fall River.
Livers, Susie Dearing, . . .	Boston.
Parker, Charles Morton, . . .	Newtonville.
Peters, Frederick Charles, . . .	Lenox.
Pierce, Henry Tyler, ...	West Millbury.
Shaw, Edward Houghton, . . .	Belmont.
Summers, John Nicholas, . . .	Brockton.
Thompson, Clifford Briggs, . . .	Halifax.
Walker, James Hervey, . . .	Greenwich Village.
Watkins, Fred Alexander, . . .	West Millbury.
Watts, Ralph Jerome, ...	Littleton.
Wood, Herbert Poland, . . .	Hopedale.
Total, ...	29

Junior Class.

Allen, Charles Francis, . . .	Worcester.
Anderson, John Albert, . . .	North Brookfield.
Anderson, Kenneth French, . .	Roslindale.
Bailey, Ernest Winfield, . . .	Worcester.
Bangs, Bradley Wheelock, . . .	Amherst.
Barry, Thomas Addis, ...	Amherst.

Bartholomew, Persis, ...	Melrose Highlands.
Bates, Carleton, ...	Salem.
Browne, Marcus Metcalf, . . .	Malden.
Chapman, Lloyd Warren, . . .	Pepperell.
Chase, Henry Clinton, . . .	Swampscott.
Clark, Orton Loring, ...	Malden.
Cobb, George Robert, ...	Amherst.
Coleman, William John, . . .	Natick.
Cummings, Winthrop Atherton, . .	Auburn, Cal.
Curtis, Jesse Gerry, ...	South Framingham.
Cutting, Roy Edward, ...	Amherst.
Daniel, John, ...	Osterville.
Davenport, Stearnes Lothrop, . .	North Grafton.
Davis, Paul Augustin, ...	Lowell.
Dolan, Clifford, ...	Hudson.
Eastman, Perley Monroe, . . .	Townsend.
Edwards, Frank Laurence, . . .	Somerville.
Farley, Arthur James, . . .	Waltham.
Farrar, Allan Dana, ...	Amherst.
Farrar, Parke Warren, . . .	Springfield.
Flint, Clifton Leroy, ...	Amesbury.
Gillett, Chester Socrates, . . .	Southwick.
Gillett, Kenneth Edward, . . .	Southwick.
Gold, Frank Lyman, ...	Amherst.
Gowdey, Carlton Cragg, . . .	St. Michael, Barbadoes.
Hayes, Herbert Kendall, . . .	North Granby, Conn.
Howe, William Llewellyn, . . .	Marlborough.
Hyslop, James Augustus, . . .	Rutherford, N. J.
Ingalls, Dorsey Fisher, . . .	Cheshire.
Jackson, Raymond Hobart, . . .	Amherst.
Jennison, Harry Milliken, . . .	Millbury.
Johnson, Frederick Andrew, . .	Westford.
Jones, Thomas Henry, . . .	Easton.
Larsen, David, ...	Bridgeport, Conn.
Liang, Lai-Kwei, ...	Tientsin, China.
Miller, Danforth Parker, . . .	Worcester.
Paige, George R., ...	Amherst.
Parker, John Robert, ...	Poquonock, Conn.
Philbrick, Edwin Daniels, . . .	Somerville.
Reed, Horace Bigelow, . . .	Worcester.
Regan, William Swift, . . .	Northampton.
Sawyer, William Francis, . . .	Sterling.

Shattuck, Leroy Altus,	Pepperell.
Thurston, Frank Eugene,	Worcester.
Turner, Olive May,	Amherst.
Turner, William Franklin,	Reading.
Verbeck, Roland Hale,	Malden.
Warner, Theoren Levi,	Sunderland.
Waugh, Thomas Francis,	Worcester.
Wellington, Joseph Worcester,	Waltham.
Wheeldon, Albert James,	Worcester.
Wheeler, Hermon Temple,	Lincoln.
White, Herbert Linwood,	Maynard.
Whiting, Albert Lemuel,	Stoughton.
Whitmarsh, Raymond Dean,	Amherst.
Wright, Samuel Judd,	South Sudbury.
Total,	62

Sophomore Class.

Adams, William Everett,	Chelmsford.
Alger, Paul Edgar,	Somerville.
Barnes, Jr., Benjamin Franklin,	Haverhill.
Bartlett, Oscar Christopher,	Westhampton.
Bean, Thomas Webster,	South Hadley Falls.
Beebe, John Cleaveland,	Hampden.
Bennett, Ernest Victor,	Malden.
Blake, Rodman Ruggles,	East Pepperell.
Briggs, Orwell Burlton,	Egremont.
Brown, Jr., George Murray,	Cambridge.
Burke, Edward Joseph,	Holyoke.
Caffrey, Donald John,	Gardner.
Cardin, Patricio Penarredonda,	Artemesia, Cuba.
Chase, Edward Irving,	Somerville.
Codding, George Melvin,	Taunton.
Coleman, Leon Nelson,	Gardner.
Corbett, Lamert Seymour,	Jamaica Plain.
Cox, Jr., Alfred Elmer,	Malden.
Cox, Leon Clark,	Boston.
Cronyn, Theodore Reid,	Bernardston.
Crosby, Harold Parsons,	Lenox.
Crossman, Samuel Sutton,	Needham.
Curran, David Aloysius,	Marlboro.

Cutler, Homer,	Westboro.
Eddy, Roger Sherman,	Dorchester.
French, Horace Wells,	Pawtucket, R. I.
Fulton, Gordon Russell,	Lynn.
Gates, Clarence Augustus,	Worcester.
Geer, Myron Francis,	Springfield.
Geer, Wayne Emory,	Springfield.
Hathaway, Elmer Francis,	Cambridge.
Hayward, Warren Willis,	Millbury.
Hsieh, En-Lung,	Tientsin, China.
Hubbard, Arthur Ward,	Sunderland.
Ide, Warren Leroy,	Dudley.
Jen, Huan,	Tientsin, China.
Kenney, Walter James,	Lowell.
Knight, Harry Orrison,	Gardner.
Learned, Wilfred Hill,	Florence.
Lindblad, Rockwood Chester,	North Grafton.
Lull, Robert Delano,	Windsor, Vt.
Lyman, Arthur Densmore,	Springfield.
MacGown, Guy Ernestus,	South Britain, Conn.
Maps, Charles Hulick,	Long Branch, N. J.
Martin, Jr., Nelson Lansing,	Sharon.
Monahan, James Valentine,	South Framingham.
Neale, Harold Johnson,	Worcester.
Noble, Harold Gordon,	Springfield.
Noyes, John,	Roslindale.
O'Donnell, John Francis,	Worcester.
O'Grady, James Raphael,	Holliston.
Oliver, Joseph Thomas,	Boston.
Paddock, Harold Charles,	West Claremont, N. H.
Pearce, Ernest Edwin,	Worcester.
Phelps, Harold Dwight,	West Springfield.
Potter, Richard,	Concord.
Putnam, Charles Sumner,	Princeton.
Richardson, George Tewksbury,	Middleboro.
Sexton, George Francis,	Worcester.
Shamiæ, George Mansoor,	Damascus, Syria.
Smith, Alexander Halliday,	Nyack, N. Y.
Smulyan, Marcus Thomas,	New York, N. Y.
Stewart, Eri Shepardson,	Royalston.
Thompson, Myron Wood,	Halifax.
Thomson, Jared Brewer,	Monterey.

Trainor, Owen Francis,	Worcester.
Treat, Carlton Eddy,	Chelsea.
Tucker, Horace Northrop,	Waterbury, Conn.
Turner, Henry William,	Trinidad, Cuba.
Warner, Frederick Chester,	Sunderland.
Webb, Charles Russell,	Worcester.
Whaley, James Sidney,	East Orange, N. J.
Whelpley, Walter Merton,	Winthrop.
White, Charles Howard,	Providence, R. I.
Willis, Luther George,	Melrose Highlands.
Wilson, Jr., Frank Herbert,	Nahant.
Total,	76

Freshman Class.

Allen, Rodolphus Harold,	Fall River.
Annis, Ross Evered,	Natick.
Bailey, Justus Conant,	Wareham.
Bartlett, Leslie Clarke,	South Hadley Falls.
Beeman, Francis Stone,	West Brookfield.
Bigelow, Windsor Howe,	Princeton.
Blaney, Jonathan Phillips,	Swampscott.
Brandt, Louis,	Everett.
Brooks, Henry Alvan,	Holliston.
Brooks, Sumner Cushing,	Amherst.
Brown, Eben Hermon,	Bridgewater.
Brown, Louis Carmel,	Bridgewater.
Burrill, Ralph Parker,	South Weymouth.
Call, Almon Eugene,	Lynn.
Cary, William Ernest,	Gansevoort, N. Y.
Chaffee, Alfred Brown,	Oxford.
Chase, George Bancroft,	North Adams.
Clarke, Walter Roe,	Milton-on-Hudson, N.Y.
Cloues, William Arthur,	Warner, N. H.
Cowles, Henry Trask,	Worcester.
Curtis, William Edward,	Worcester.
Damon, Edward Farnham,	Concord Junction.
Dickinson, Lawrence S.,	Amherst.
Drohan, Joseph Chauncey,	Belchertown.
Eldridge, Cecil Vernon,	Harwichport.
Everson, John Nelson,	West Hanover.

Faelten, Willibald Carl, . . .	Roxbury.
Fisk, Raymond John, ...	Stoneham.
Folsom, Josiah Chase, ...	Billerica.
Francis, Henry Russell, . . .	Dennisport.
Gould, Harold Alvin, ...	Cambridge.
Hastings, David Beard, . . .	New York Mills, N. Y.
Hatch, William Marcus, . . .	Springfield.
Haynes, Frank Tuttle, . . .	Sturbridge.
Hazen, Myron Smith, ...	Springfield.
Holland, Arthur Witt, . . .	Shrewsbury.
Howe, Chester LeRoy, . . .	Watertown.
Huang, Chen-Hua, ...	Tientsin, China.
Johnson, William Clarence, . . .	South Framingham.
Kelley, Albert Crittenden, . . .	Harwichport.
Kelly, Edward Nicholas, . . .	Globe Village.
Lambert, Marjorie Willard, . . .	W. New Brighton, N. Y.
Leonard, Leavitt Edwin, . . .	Pittsford Mills, Vt.
Leonard, William Edward, . . .	Belmont.
Lightbody, Winfred Curran, . .	South Framingham.
Lipman, Isaac Birkhahn, . . .	Woodbine, N. J.
McGraw, Frank Dobson, . . .	Fall River.
McLaine, Leonard Septimus, . .	New York, N. Y.
Mendum, Samuel Weis, . . .	Roxbury.
Moore, Harold Ithiel, ...	Leominster.
Newcomb, Raymond Wallace, . .	Fitchburg.
Nickless, Fred Parker, . . .	Carlisle.
Nielsen, Gustaf Arnold, . . .	West Newton.
Oertel, Charles Andrew, . . .	South Hadley Falls.
Orr, Lewis Jordan, ...	Portland, Me.
Orr, Philip Eastman, . . .	Portland, Me.
Partridge, Frank Herbert, . . .	Cambridge.
Prouty, Frank Alvin, ...	Worcester.
Robb, Allen James, ...	Wilbraham.
Rockefeller, Harlan Victor, . .	Germantown, N. Y.
Schermerhorn, Lyman Gibbs, . .	Kingston, R. I.
Smith, Halliday Spencer, . . .	Nyack, N. Y.
Smith, Stanley Sawyer, . . .	Athol.
Stalker, William Alexander, . .	Framingham.
Stockwell, Chellis Wheeler, . . .	Athol.
Sullivan, Arthur James, . . .	Dalton.
Taylor, Israel Houston, . . .	Leverett.
Thomas, Frank Lincoln, . . .	Concord.

Titus, Willard McCready Snow,	New Braintree.
Turner, Edward Harrison,	Reading.
Urban, Otto Velorous Taft,	Upton.
Vinton, George Newton,	Sturbridge.
Waldron, Ralph Augustus,	Hyde Park.
Wallace, William Newton,	Amherst.
Whitney, Raymond Lee,	Brockton.
Woodward, Walter Francis,	Worcester.
Total,	76

Short Winter Course, Dairy Farming, 1906.

Arnold, Hewett Fields,	Salisbury, Vt.
Bardwell, Jr., Charles Edward,	Ashland.
Beaubien, Joseph,	Montague.
Bisbee, Fred,	Barre.
Bump, Arthur Cyrus,	Salisbury, Vt.
Clark, George Arthur,	East Charlemont.
Corbin, Leslie Rogers,	Springfield.
Cowern, Herbert George,	Southborough.
Curry, Francis,	Cranston, R. I.
Filley, Oliver Dwight,	Hartford, Conn.
Fillion, George,	South Hadley.
Fuller, Albert Gladstone,	Holyoke.
Heath, Lester Gifford,	Springfield.
Hillman, Arthur Joseph,	Hardwick.
Hilton, Frederick Herbert,	Barre.
Hobbs, Walter Frederick,	Amherst.
Holmes, Helen,	Kingston.
La Fleur, Horace Charles F.,	Northampton.
Leonard, Jr., John Wood,	Plymouth.
Mackenzie, Frank David,	Boston.
Martin, Jr., Nelson Lansing,	Sharon.
Newhall, John Anson,	Newburyport.
Plumb, Harold Edgar,	Readsboro, Vt.
Randall, George Ashley,	Amherst.
Scott, Walter,	East Lyme, Conn.
Strong, Anson Loomis,	Colchester, Conn.
Taylor, Raymond William,	Tyringham.
Trask, Howard Weston,	Peabody.

Wilder, Frank Everett,	Petersham.
Wise, Lewis Henry,	Boston.
Total,	30

Course in Bee Culture, 1906.

Beebe, Katherine Smith,	Holyoke.
Bullard, Harriett Cox,	Franklin.
Cunningham, Minnie,	Holyoke.
Hutchinson, William Ford,	Sutton.
Lambert, Marjorie Willard,	West New Brighton, Staten Island, N. Y.
Rand, Jean C.,	Holyoke.
Total,	6

Graduate Students.

For Degrees of M.S. and Ph.D.

Back (B.Sc., M. A. C., '04), Ernest Adna,	Florence.
Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.
Hooker (B.A., Amherst, '06), Charles Worcester,	Amherst.
Ladd (B.Sc., M. A. C., '05), Edward Thorndike,	Winchester.
Lancaster (A.B., Harvard, '84; M.D., Harvard, '89), Walter Brackett,	Boston.
Monahan (B.Sc., M. A. C., '03), Niel Francis,	Amherst.
Osmun (M.S., M. A. C., '05), Albert Vincent,	Danbury, Conn.
Russell (B.Sc., M. A. C., '06), Harry Merwin,	Bridgeport, Conn.
Smith (B.Sc., M. A. C., '97), Philip Henry,	Amherst.
Tottingham (B.Sc., M. A. C., '03), William Edward,	Bernardston.

Tower (B.Sc., M. A. C., '03), Winthrop Vose,	Roxbury.	
Walker (B.Sc., M. A. C., '05), Lewell Seth,	Natick.	
Total,		12

Special Students.

Macaulay, Mrs. John,	New York, N. Y.	
Turner, James Arthur,	Springfield.	
Total,		2

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	12	
Four-years course: —		
Graduates of 1906,	28	
Senior class,	29	
Junior class,	62	
Sophomore class,	76	
Freshman class,	76	
Winter courses,	30	
Special students,	8	
Total,		321
Entered twice,		3
Total,		318

OBJECT.

The leading object of the Massachusetts Agricultural College is "to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

GRADUATE COURSES.

In response to the increasing demand for advanced work in various directions, the college has arranged for courses of study leading to the degrees of Master of Science and Doctor of Philosophy.

Honorary degrees are not conferred.

Applicants are not eligible to the degree of Master of Science or Doctor of Philosophy until they have received the degree of Bachelor of Science or its equivalent.

The fee for the degree of Master of Science is ten dollars and for the degree of Doctor of Philosophy twenty-five dollars, to be paid to the treasurer of the college before the degree is conferred.

Courses for the Degree of Master of Science.

A course of study is offered in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary medicine. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

Candidates for the degree of Master of Science must devote not less than one year and a half after graduation to the prosecution of two of the above courses. At least one full academic year must be passed in residence at the Massachusetts Agricultural College.

When a graduate student is working for a Master's Degree, and at the same time is, or has been, employed with or without pay in some department of this college or of the experiment station in the same kind of work as his major or minor studies, or both, the teacher in charge of his graduate work in the subject or subjects concerned may allow for so much of this work as in his judgment would be legitimate graduate work were the

student not so employed. This rule shall not, however, be regarded as modifying any rule now in force as to residence while working for a Master's Degree.

Courses for the Degree of Doctor of Philosophy.

The establishment of courses leading to this degree is the result of many calls for advanced study along certain economic lines neglected in most American universities, and is given only by those departments especially equipped for this grade of study, to graduates of this college or other colleges of good standing. The work required for the degree is intended to be so advanced in its character as to necessitate the greatest industry to complete it, with the belief that such severe requirements will result in the greatest credit to those who are successful. Four courses of study only are therefore open, viz., botany, chemistry, entomology and horticulture as major subjects, though a minor in zoölogy is also available.

At least three years are necessary to complete the work required; twenty hours per week to be devoted to the major subject, while from twelve to sixteen hours per week are required for each of the two minor subjects during one and a half years.

The work in the major and minors will necessarily differ with the previous training and needs of different students, but a general outline of the major in each subject is as follows: —

Botany. — Vegetable physiology, vegetable pathology, mycology, œcology, taxonomy, phylogeny, the history of botany, and the history and theory of evolution. The above subdivisions of botany will be, to a greater or less extent, pursued as necessitated by the previous training of the student and nature of the original problem undertaken. In this course it is also recommended that the student take, in addition to this prescribed minor work, a brief course in the history of philosophy and psychology, which at present will have to be obtained elsewhere. Extensive reading of botanical literature, of both a general and specific nature, will be required in certain subjects, and occasional lectures will be given. A botanical conference is held monthly, wherein various new problems touching upon botanical science are considered by graduate students and those of the senior class electing botany. A thesis dealing with some economic problem in plant physiology or pathology, or both, and containing a distinct contribution to knowledge, will also be required.

Chemistry. — Advanced work in the following subjects: inor-

ganic analysis, qualitative, of the rarer elements, and quantitative; crystallography, physical chemistry; descriptive and determinative mineralogy; chemical geology; soil formation; soil physics and chemistry; gas analysis; synthetic inorganic work; chemical theory and history; general organic chemistry; special topics in organic chemistry; elementary quantitative organic analysis; proximate qualitative and quantitative organic analysis, including determination of organic radicles; organic synthesis of aliphatic and aromatic compounds; problems in chemical manufacture; recent chemistry of plant nutrition; animal physiological and pathological chemistry, including foods, standards for feeding of all kinds, and, among secretions, milk and milk industries; and, among excretions, urine and urinalysis; toxicology; insecticides and fungicides; frequent examinations on current chemical literature.

Early in the course original work on some chemical subject pertaining to agriculture must be begun. The history and results of this work must be submitted before graduation, in the form of a thesis containing a distinct contribution to knowledge.

Entomology. — General morphology of insects; embryology; life history and transformations; histology; phylogeny and relation to other arthropods; hermaphroditism; hybrids; parthenogenesis; pædogenesis; heterogamy; chemistry of colors in insects; luminosity; deformities of insects; variation; duration of life.

Œcology: dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects, insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases; photography of insects and their work; methods of drawing for illustrations; field work on insects, and study of life histories; legislation concerning insects.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

Journal club: assignments of the literature on the different groups of insects to different students, who report at monthly meetings summaries of all articles of value which have appeared during the month.

Required readings of the best articles on the various topics named above, and on the different orders of insects. This reading covers from 15,000 to 20,000 pages in English, French and German, and the candidate is examined on this, together with his other work, at the close of his course.

Thesis: a thesis with drawings, which shall consist of the results of original investigations along one or several lines, and which shall constitute a distinct contribution to knowledge, must be completed and accepted before the final examinations are taken.

Horticulture. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation, and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote himself continuously to it. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects. Advanced work will be required in the following subjects: systematic pomology, pomological practice, commercial pomology; systematic, practical and commercial olericulture; greenhouse plants and problems; floriculture; landscape gardening; plant breeding and general evolution; and questions of a physiological nature connected with propagation and pruning.

Other requirements and opportunities are: (1) periodical seminars with special lectures, by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits to orchards, gardens, greenhouses, estates and libraries outside the college grounds, always with some definite purpose in view; (4) and, finally, the preparation and publication of a thesis setting forth the results of the candidate's major study, which shall be an original and positive contribution to horticultural knowledge.

Zoölogy, offered as a minor for the degree of Doctor of Philosophy. This course deals with the larger problems and aspects which the subject presents, and with which the student in any department of zoölogy should be familiar. Zoölogy 3, or its equivalent, is prerequisite. The aim is to give the student a liberal equipment for further work, to introduce him to some

fields outside his specialty, as well as to meet his more imperative needs as a specialist.

Lecture attendance and collateral reading, and laboratory and seminar work are required. The student is early set to work upon some problem of practical importance in the study of which he may learn the inseparable relationship of the pure and the practical in scientific inquiry.

FOUR-YEARS COURSES.

Degree.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni, provided that the candidate, in addition to the college course, shall have mastered in a preparatory school a three-years preparatory course in studies beyond those commonly presented in the grammar schools of Massachusetts.

Admission.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Certificates. — Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

Examinations. — Candidates for admission to the freshman class will be received on certificate, as explained above, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology

(Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1907 and 1908 are: Shakespeare's "The Merchant of Venice;" Irving's "Life of Goldsmith;" Coleridge's "The Ancient Mariner;" Scott's "Ivanhoe" and "The Lady of the Lake;" Tennyson's "The Passing of Arthur;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1907 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 20 and 21, and on Tuesday and Wednesday, September 17 and 18, as follows: —

First Day.	*Second Day.*
8.30 A.M. — Registration.	9 A.M. — Civil government.
9 A.M. — English.	10 A.M. — Algebra.
11 A.M. — General history.	2 P.M. — Physiology.
2 P.M. — Geometry.	3 P.M. — Physical geography.

Entrance examinations in June will be held on the same days and in the same order as in Amherst: at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Horticultural Hall, Worcester; and at Pittsfield, but candidates may be examined and admitted at the convenience of the examiners, at other times in the year, but not during the summer vacation.

ENTRANCE EXAMINATION PAPERS USED IN 1906.

The standard required is 65 per cent. on each paper.

Algebra.

1. Factor: (a) $a^{-2}x^{-m}+14a^{-1}x^{-\frac{m}{2}}+49$.
(b) $2ax-3bx+2a-3b$.
(c) $a^4+a^2y^2-a^2b^2-b^2y^2$.

2. Clear of negative exponents, and simplify the result in the expression $\left\{\dfrac{a^{-2}b^{-2}}{a^{-2}+b^{-2}}\right\}\quad\left\{\dfrac{a^2+b^2}{a^{-1}-b^{-1}}\right\}$.

3. Find the square root of the expression

$$x^{\frac{5}{3}}-4x^{\frac{4}{3}}+2x+4x^{\frac{2}{3}}+x^{\frac{1}{3}}.$$

4. Expand $(\sqrt{-2}+\sqrt{-3})^3$ and reduce to simplest form.

5. Find the square root of the binomial surd $4\frac{1}{2}x-1+2\sqrt{2}$.

6. $\sqrt{3+x}+\sqrt{3-x}=2\sqrt{x}$. Solve for x.

7. $\left\{\begin{array}{l} x^{-3}+y^{-3}=152 \\ x^{-1}+y^{-1}=8 \end{array}\right\}$ Solve for x and y.

8. $\left\{\begin{array}{l} x^2+xy=12 \\ xy-2y^2=1 \end{array}\right\}$ Solve for x and y.

Geometry.

1. Prove: If the two sides of a triangle are unequal, the angles opposite are unequal, and the greater angle lies opposite the greater side.

2. Prove: The angle between two secants, intersecting without the circumference, is measured by one-half the difference of the intersected arcs.

3. Two triangles, having an angle of one equal to an angle of the other, are to each other as the product of the sides including the equal angles. Prove.

4. If the radius of a circle is $3\sqrt{3}$, what is the area of a sector whose central angle is 152°?

5. Find the area of a square inscribed in a circle whose area is 196π.

Physical Geography.

1. Describe in detail the general physical features of the continent of North America; its form, coast line, mountains, river systems and lakes.

2. Describe at least three methods of mountain formation. What do you mean by youth, maturity and old age of a mountain? Illustrate.

3. Describe the Sahara; its climate, vegetation and inhabitants. What was the probable cause of its present condition?

4. Describe Mount Vesuvius and the recent eruption. What were its causes and effects? Is such an eruption likely to occur again?

5. What are the principal races of mankind? Give the main characteristics of each, with the state of civilization and geographical distribution.

Civil Government.

1. What was the government of Massachusetts before the revolution? State its principal features. What was the government of the United States during the revolution? When did the constitution of the United States go into effect? Write its preamble.

2. What three "powers" of government are defined in the constitution? What duty belongs to each of these powers?

3. Write on the following subjects, developing them as fully as you can: —

(*a*) The United States Senate.

(*b*) The Legislature of Massachusetts.

(*c*) The government of any city or town of Massachusetts.

4. Name the coins of the United States. What is the distinction between a mint and an assay office? Where is the principal mint of the United States located? Where the branch mints?

5. Describe the national bank system of the United States. What are treasury notes?

6. Define *naturalization*. State the principal points in the

"uniform rules of naturalization" established by Congress. What classes of persons are included in the term, "citizens of the United States"?

Physiology.

1. Describe the chemical constitution of the body, with the elements, and the organic and the inorganic compounds found therein.

2. Name and locate the bones of the skull, bounding each bone as you would the countries on a map. Describe with a diagram the histology of bone.

3. What three forms of energy are manifest in the human body? How is this energy produced, and what is its ultimate source?

4. What do you mean by nutrition? What is its purpose? Name and define the several steps in the nourishing of the human body.

5. Describe the brain carefully; its protective envelopes, and the relative size, form and proportions of its various parts. What are the probable functions of each of the principal parts?

General History.

1. The Hebrew religion and literature: relation of this religion to the Christian world of to-day, and the great works of Hebrew literature which have been used by the Christians and the Jews as sources of teaching.

2. Greek character and Greek history as influenced by: (*a*) mountains, (*b*) surrounding sea and islands.

3. Greek oratory: (*a*) influence of the public assembly; (*b*) Demosthenes, and how he prepared himself to be an orator.

4. Give in a few words the part played in Roman history by Julius Cæsar, mentioning: (*a*) his work as a subduer of barbarians, (*b*) his struggle with Pompey, (*c*) his career as a statesman.

5. Explain clearly the relation which existed during the middle ages between Church and State.

6. Explain the term, "The Reign of Terror," as used in French history.

English.

Note. — "A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, phraseology or division into paragraphs." (From the college catalog.)

1. State in a general way, yet fully and clearly, what work you have done in the high school: —

(*a*) In the study of rhetoric.

(*b*) In composition writing.

(*c*) In the study of literature.

2. Have you read all the books assigned for examination in entrance English? Were these books read in connection with class work, or as outside work?

3. Choose any two names from the following list, and write an interesting, brief account of the authors' lives: —

(*a*) Shakespeare, (*b*) Scott, (*c*) Irving, (*d*) Lowell.

4. What can you say of Tennyson's love of retirement?

5. Choose from among the following topics any four; write interestingly upon them: —

(*a*) Is Shylock to be pitied, or to be hated?

(*b*) Is Irving a sympathetic biographer of Goldsmith?

(*c*) The underlying value of Scott's "Ivanhoe."

(*d*) The opening scene in the "Lady of the Lake."

(*e*) Tennyson's view of woman's place in society, as given in "The Princess."

(*f*) Carlyle's estimate of Burns' sincerity, and his (Burns') choice of subjects.

(*g*) The center-thought of the "Vision of Sir Launfal."

(*h*) A brief outline of the chief characters in "Silas Marner."

COURSES OF INSTRUCTION FOR THE DEGREE OF BACHELOR OF SCIENCE.

Agriculture.

Introductory: relations of federal and State governments to agriculture, four lectures; history of agriculture, tenure of land, rents, holdings, etc., six lectures.

Freshman year, first semester, three hours a week, required. Animal breeding. Shaw's "Breeding Animals," lectures and discussion of principles of breeding. — Assistant Professor Cooley.

Sophomore year, seven weeks, first semester, four exercises a week in class room, required. Breeds of farm live stock: sheep, cattle. Lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, nine weeks, first semester, four exercises a week in class room, required. Horses and swine. Lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, eight weeks, second semester, three hours a week, required. Dairying. Lectures on dairy farming, milk production, handling and marketing of milk, milk preservation and modification, and products of milk. Text-book, Wing's "Milk and its Products." — Assistant Professor Cooley.

Sophomore year, ten weeks, second semester, required. Soils: formation, classification, composition; physical and chemical characteristics, and their relations to maintenance and increase in productiveness. Brooks's "Agriculture," Vol. I., supplemented by lectures and laboratory work. — Professor Brooks.

Junior year, ten weeks, first semester, elective. Methods of soil improvement, including tillage, drainage and irrigation. Brooks's "Agriculture," Vol. I., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Manures: production, composition, properties, adaptation and use. Brooks's "Agriculture," Vol. II., supplemented by lectures and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Stock judging. — Assistant Professor Cooley.

Junior year, second semester, elective. Fertilizers, including a critical study of their production, composition, properties, adaptation and use; and green manuring. Brooks's "Agriculture," Vol. II., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Senior year, four weeks, first semester, four hours a week, elective. Silos and ensilage: historical development; the merits and methods of construction of the different kinds of silos; the crops suited for ensilage; ensilage machinery; the methods of filling the silo; and the nature and extent of the changes taking place in ensilage as affecting food value. Lectures, books of reference and practical exercises. — Professor Brooks.

Senior year, seven weeks, first semester, four hours a week, elective. Feeding animals: principles of digestion and animal

nutrition, a study of feeding stuffs (coarse and concentrated). The relation of food to product; compounding rations. Armsby's "Cattle Feeding," lectures and discussion. — Assistant Professor Cooley.

Senior year, seven weeks, first semester, four hours a week, elective. Dairying: selection and management of the dairy farm, dairy cattle, chemical and physical properties of milk, etc., cream, butter, cheese and by-products. — Assistant Professor Cooley.

Senior year, first semester, four exercises a week for eight weeks. Dairy practice: use of separators, Babcock tester, butter making, etc. — Specialists.

Senior year, second semester, elective. The crops of the farm and crop rotation; including a study of the origin and agricultural botany of all the leading crops of the farm, — annual forage crops, grasses and legumes, cereals, root crops, vegetables, tobacco and other special commercial crops: the production and uses of each; the varieties and methods of improvement; the adaptation to soil; the special manurial requirements and the methods of raising and harvesting are considered. Lectures, reference books and field work. — Professor Brooks.

Senior year, second semester, elective. Agricultural experimentation: objects, methods, sources of error; interpretation of results. Lectures and study of reports, bulletins, etc. — Professor Brooks.

Senior year, second semester, elective. Farm management: selection of the farm, its subdivision and equipment, buildings, fences, roads, water supply; farm capital, permanent, perishable and floating; the labor of the farm and its management; farm power and farm machinery. Lectures and practical exercises. — Professor Brooks.

Seminar courses, by arrangement, for advanced students.

Special problems requiring experiment or other research investigation will be assigned to students fitted for and desiring such work.

Training and practice in the use of farm implements and machines by arrangement when desired.

Horticulture.

This department endeavors to give the student a working knowledge of horticulture on its practical and on its scientific side. The attempt is made to inculcate a taste and an enthusiasm

for horticultural pursuits, in place of distaste and dislike for the drudgery of farm life. On these things success and further progress chiefly depend.

The courses now offered are as follows, though others will be added as occasion requires: —

1. Sophomore class, second semester. The fundamental operations of horticulture, — propagation, pruning and cultivation, — as related to the physiology of the plant. During the first half of this course Bailey's "Nursery Book" is used as a text. — Mr. Blake.

2. Junior year, first semester. Pomology: this course covers the three natural divisions of the subject, viz.: (*a*) systematic pomology, or the study of the fruits themselves; (*b*) practical pomology, or the practice of fruit growing; (*c*) commercial pomology, or the principles underlying the marketing of fruits. The course is pursued by means of text-book, lectures, laboratory and field exercises. — Mr. Blake.

3. Junior year, first semester, four periods weekly. Plant breeding: based on a thorough examination of the laws of heredity and of variation, and of the principal theories of evolution. Lectures, accompanied by practice and direct experiments in crossing and hybridizing plants. — Professor Waugh.

4. Junior year, second semester, four periods weekly. Market gardening, including vegetables and small fruits; locations, soils, methods of cultivation and marketing. Text-book, lectures and field exercises. — Mr. Blake.

5. Individual problems will be assigned to seniors who elect horticulture. This gives the student an opportunity for specialization in various lines of fruit growing, vegetable culture, greenhouse management, landscape gardening, etc. — Professor Waugh, Mr. Blake and Mr. Canning.

A seminar, made up of all students electing advanced work in horticulture or landscape gardening, meets weekly for the discussion of any matters pertaining to the subject. Successful and noted horticulturists from outside the college are frequently present at these meetings, to speak on the topics with which they are especially identified.

Landscape Gardening.

The college wishes to promote the work in landscape gardening in every way possible. The aim of the courses is to give the general student an understanding of the fundamental principles of

design and of good taste as applied to gardening, and to prepare advanced students for the practice of landscape gardening in its various branches.

Although a variety of other work along related lines is available, the courses now definitely offered are as follows: —

1. Junior year, first and second semesters, four hours a week. Elements of landscape design: the fundamental principles underlying the artistic development of parks, estates, gardens and other areas, together with some of the simpler applications to practical conditions. — Professor WAUGH and Mr. HALLIGAN.

2. Junior year, first semester, three periods weekly. Arboriculture: trees, shrubs and other ornamental plants; their propagation, planting and care. Field and laboratory exercises and lectures. — Professor WAUGH, Mr. CANNING and Mr. HALLIGAN.

3. Senior year, first and second semesters, four laboratory periods weekly. Advanced landscape gardening: lectures, conferences, field exercises and extensive practice work with criticism. The student is given definite problems to solve, these problems being arranged in such an order as to develop the subject logically in the student's mind. — Professor WAUGH.

CHEMISTRY.

This course aims to inculcate accurate observation, logical thinking, systematic and constant industry, together with a comprehensive knowledge of the subject. Instruction is given by text-book, lectures and a large amount of laboratory work under adequate supervision. The laboratory work at first consists of a study of the properties of elementary matter, analysis of simple combinations and their artificial preparation. This is followed by a quantitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products. The advanced instruction takes up the chemistry of various manufacturing industries, especially those of agricultural interest, such as the production of sugar, starch and dairy products; the preparation of animal and plant foods, their digestive assimilation and economic use; the official analysis of fertilizers, fodders and foods; and the analysis of soils, waters, milk, wine and other animal and vegetable products.

The courses are as follows: —

Freshman year, second half of second semester, four hours a week. General chemistry, part 1, principles of chemistry, nonmetals. Newth's "Inorganic Chemistry." — Assistant Professor HOWARD.

Sophomore year, first semester, six hours a week. General chemistry, part 2, metals. — Assistant Professor Howard.

Second semester, five hours a week. Subject continued; dry analysis. — Assistant Professor Howard.

Junior year, first semester, eight hours a week. Qualitative and quantitative analysis; organic chemistry. Four hours a week, special subject. — Professor Wellington.

Second semester, ten hours a week. Organic chemistry. Remsen's "Organic Chemistry." Five hours a week, special subject. — Professor Wellington.

Senior year, elective, first semester, three hours a week. Chemical industries. — Professor Goessmann.

Eight hours a week, quantitative analysis and physical chemistry. Reychler-McCrae's "Physical Chemistry." — Professor Wellington and Assistant Professor Howard.

Second semester, eight hours a week. Advanced work, with lectures. — Professor Wellington.

Geology.

1. Mineralogy, junior year, second semester, six weeks, three hours a week. A course of systematic determinative mineralogy, based on Brush's "Manual." This work is carried on in the laboratory, and consists in determining the minerals by a study of lustre, fusibility, hardness, color, streak, specific gravity, etc., and by some of the simpler chemical tests. — Assistant Professor Howard.

2. Geology, elective in junior year, second semester, three hours a week. Petrography; the rock-forming minerals, rocks, rock characters. Structural geology. Dynamic geology; the agents of rock disintegration are emphasized. Surface geology; soils, erosion, transportation, reconstructive processes, land making. Historic geology. — Assistant Professor Gordon.

Zoölogy.

1. Anatomy and physiology, freshman year, one-half second semester, four hours a week. The body is dealt with largely as a mechanism. Hygiene, sanitation as related to sewer and garbage disposal, water supply, construction of habitations and hygiene of transmissible diseases are emphasized. — Assistant Professor Gordon.

2. Zoölogy, sophomore year, first semester, two periods a week. This forms the zoölogical part of an introductory course in biology. The aim is to familiarize the student with the

structure of a number of typical forms, representative of the chief phyla of the animal kingdom, to train him to more precise habits of observation, and to lay the foundation for a more thorough understanding of laboratory technique. Lectures, amply illustrated by specimens, charts and lantern slides, supplement and render orderly the knowledge gained in the laboratory. — Assistant Professor GORDON.

3. Zoölogy. For this course zoölogy 2 or its equivalent is prerequisite. Elective for the junior year, four periods a week. This course attempts an introduction to each group. In those groups which are of economic importance the emphasis is placed on that aspect. As the final work of some students and as the ground work of others who plan to go farther, the course is made as thorough as the time available, in and out of the class room, will permit. The student is not led to believe that any text-book represents the sum total of human knowledge on all the biological problems of the day, but is rather encouraged to think and ponder. To this end the discussion of the origin of one or two morphological features in those groups in which these features present themselves, or the discussion of a morphological series as suggestive of an evolutionary one, is consistently carried through. Other fields for investigation are continually suggested. The lectures are illustrated by the complete museum collections. — Assistant Professor GORDON.

ECONOMICS AND GOVERNMENT.

The aim of this department is to introduce the student to such studies as may enable him to deal with economic problems and to fulfill his social and political duties. In all work of the department the text-book and lecture systems are combined.

1. History, freshman year, two hours a week, both semesters. In this course the history of England to the close of the middle ages is studied; then the history of England and the American colonies, in conjunction, to the year 1783; and then the modern history of England and the United States. Emphasis is laid on social and economic conditions, but the more important political, religious and other phases of English and American history are treated in the lectures. Cheyney's "Social and Industrial History of England" and Coman's "Industrial History of the United States" are used as text-books. This course is preparatory to courses 2 and 3. — Mr. HOLCOMB.

2. Economics, junior year, first semester, four hours a week.

Ely's "Outlines of Economics" and Taylor's "Introduction to Agricultural Economics" are used as text-books. The lectures on general economics are intended to supplement Ely's book, with emphasis on present-day problems. The lectures on agricultural economics treat of the history of the agricultural industry, and existing agricultural economic conditions and tendencies in the United States. Such subjects as the resources of the various geographical divisions of our country in land and labor, the application of division of labor to agriculture, specialized and diversified farming, the large and small farm systems, tenure of farm lands, the transportation of farm products, tendencies toward agricultural co-operation, and those characteristics of agriculture which make it especially attractive to the liberally educated mind, are briefly treated. Special papers on subjects selected by the individual students from an assigned list are read and discussed in the class room.

3. Government, senior year, four hours a week, during the last half of the first semester and the whole of the second. Woodburn's "The American Republic" is used as a text-book, supplemented by assigned readings in Hart's "Actual Government" and Buchanon's "Massachusetts Town Officers." The lectures treat of general sociology, the theory and forms of the State, the origin and history of American political institutions, political parties and movements in the United States, and eminent political leaders and interpreters of the Constitution. Special attention is given to the United States Department of Agriculture, State Board of Agriculture, agricultural education and the organization of the New England country town. — Mr. Holcomb.

Lectures on law, second semester, one hour a week. This course treats of laws relating to business, especially to business connected with rural affairs, citizenship, domestic relations, farming contracts, riparian rights, real estate and common forms of conveyance. Practical work is required, such as may fit one to perform the duties of a justice of the peace. — Mr. Lyman.

English.

This department aims to secure: (*a*) ability to give written and oral expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present logically and forcibly, oral and written arguments on propositions assigned for debate.

The following courses are offered: under (*a*) rhetoric and oratory; under (*b*) American literature and English literature; under (*c*) argumentation. The elective course in senior year is in language and literature.

1. *Rhetoric.* — This course extends through the two semesters of freshman year and through the second semester of sophomore year. In the first semester of freshman year work is confined to essay writing and to personal criticism, by the instructor, of the student's compositions. This criticism is offered at stated intervals to each student individually, according to a posted schedule of appointments. At the beginning of the semester necessary information with regard to the preparation of essays is furnished each student. In the second semester of freshman year the study of literary types is undertaken in the form of class room work in prose composition, including exposition, persuasion, narration, description and in prose diction, including usage and style. Special attention is given to the training of the inventive ability of the student. The text-book used is Baldwin's "College Manual of Rhetoric." In the second semester of sophomore year individual work in essay writing is again taken up, largely based upon the previous work of the class in American literature (see 3, below). Here also personal criticism is offered. — Assistant Professor NEAL.

2. *Oratory.* — Individual drill in declamation, first in private and then before the class, is given during the second semester of freshman year. The choice of speakers for the Burnham prizes is based upon this work. In the junior year, during the first semester, at least two orations, upon subjects assigned or chosen, are written, and delivered before the class. Every oration is criticised by the instructor before it is committed to memory by the student. The choice of speakers for the Flint prizes in oratory is based upon this work. — Professor MILLS and Assistant Professor NEAL.

3. *Literature.* — American literature is studied in the first semester of sophomore year, three hours a week. The course comprises, first, the careful study of a text-book (Newcomer's "American Literature"), together with recitations based upon the same; secondly, the taking of notes from lectures, dwelling upon topics not fully treated in the text-book; and, thirdly, the reading outside of the class room of assigned selections from the prose and poetical works of standard American authors. — Assistant Professor NEAL.

The history of English literature is studied during the second semester of sophomore year, four hours a week. The work is based upon a text-book, this year Johnson's "History of English and American Literature." The topical method is followed in recitation, and, instead of formal lectures, there are discussions of points requiring a fuller development than the text-book gives. Collateral readings of literature are required. Frequent written tests are given, in which particular attention is given to (*a*) the definition of words used in the text-book; (*b*) the use of English in the development of the topics unfolded in the text-book or discussed in the class room. — Professor MILLS.

4. *Argumentation.* — Four hours a week during the first semester of junior year are given to written and oral argumentation. The course is outlined as follows: (*a*) principles of argumentation as laid down in a text-book or by lecture; (*b*) briefs and brief-making; (*c*) briefs developed into forensics and submitted for personal criticism: (*d*) debates. — Professor MILLS.

Senior elective course, two semesters, four hours a week. The work in this course is upon the following subjects: (*a*) English language, its origin, history and development, with particular attention to the study of words as outlined in Anderson's "A Study of English Words;" (*b*) English literature, principally of the eighteenth and nineteenth centuries. — Professor MILLS.

VETERINARY SCIENCE.

The course of instruction in veterinary science has been arranged to meet the demands of the students who, after graduation, purpose following some line of work in practical agriculture. Particular stress is laid upon matters relating to the prevention of disease in animals. In addition, the interests of prospective students of human and comparative medicine have been taken into account in the arrangement of the course of study. The subject is taught by lectures, laboratory exercises, demonstration and clinics.

Senior year, elective, first semester, four hours a week. Veterinary hygiene, comparative (veterinary) anatomy, general pathology. — Professor PAIGE.

Second semester, four hours a week. Veterinary materia medica and therapeutics; theory and practice of veterinary medicine; general, special and operative surgery; veterinary bacteriology and parasitology; medical and surgical clinics. — Professor PAIGE.

Bacteriology.

The instruction in bacteriology is given by means of lectures, recitations and laboratory exercises. The object of this course of study is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and their relation to such processes as decomposition, fermentation, digestion and production of disease. The toxic substances resulting from the growth of organisms are considered, as well as the antitoxin used to counteract their action.

Senior year, first half of the first semester, four laboratory exercises, of two hours each a week, required. — Professor Paige.

Botany.

The object of the course in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. The undergraduate work extends through six semesters. The first two semesters are required. An outline of the course follows: —

Freshman year, first semester, five hours a week. Laboratory work and lectures; histology and physiology of the higher plants. This includes a study of the minute structure of the plant organism, such as stems, roots, leaves, seeds, etc., and of their functions and chemical and physical properties. This course extends into the next semester. — Mr. Osmun.

Freshman year, second semester, three hours a week. Laboratory work, lectures and text-book; outlines of classification and morphology of the higher plants. This course follows the preceding one, and commences about the first of March. It is devoted to a study of the relationship of plants, their gross structure, together with extensive individual practice in flower analysis. An herbarium of two hundred species of plants is required. — Mr. Osmun.

Junior year, first semester, five hours a week. Two laboratory exercises and one lecture period a week. Cryptogamic botany. This includes a study of the lower forms of plant life, and is necessary for a comprehension of the following courses. — Mr. Osmun.

Junior year, second semester, five hours a week. Two laboratory exercises and one lecture period a week. Elements of vegetable pathology and physiology. This course includes a study of the common fungous disease of crops, and consideration of the

method of prevention and control of the same. The plant's function as related to susceptibility to disease is also taken up. All of the junior botany is included in four of the junior elective courses. — Professor STONE.

Senior year, elective, both semesters. Three laboratory exercises and one lecture period a week. (*a*) Plant physiology; (*b*) plant pathology. Both courses are optional. These courses are adapted to students who desire a more detailed knowledge of plant diseases and plant physiology. Extensive use is made of the valuable and constantly increasing experiment station literature. — Professor STONE.

MATHEMATICS, PHYSICS AND ENGINEERING.

This department has charge of the instruction in mathematics, physics, civil engineering and drawing. The aim is to secure thorough work in the fundamental principles, and train the mind in clear and logical thinking. The application of the subjects to practical problems is given special attention. The work of the department extends over the four years, as outlined below.

Mathematics.

Freshman year, first semester, five hours a week. Higher algebra, including ratio and proportion, progressive binomial theorem, series, undetermined coefficients, logarithms, continued fractions, permutations. Wells' "College Algebra." — Professor OSTRANDER and Professor HASBROUCK.

Second semester, two hours a week. Solid geometry. Wells' "Solid Geometry." — Professor HASBROUCK.

Plane trigonometry, two hours a week. Lyman and Goddard's "Trigonometry." — Professor OSTRANDER.

Junior year, for mathematical and chemical students, first semester, four hours a week. Analytic geometry of the line, circle, conic sections and higher plane curves. Nichols' "Analytic Geometry." — Professor HASBROUCK.

Second semester, four hours a week. Differential and integral calculus. Osborne's "Calculus." — Professor HASBROUCK.

Physics.

Sophomore year, first semester, four hours a week. Elementary mechanics of solids, liquids and gases, heat and sound. Merriman's "Elements of Mechanics," Carhart's "University Physics." — Professor HASBROUCK.

Second semester, four hours a week. Electricity, magnetism and light. Carhart's "University Physics." — Professor HASBROUCK.

Senior year, elective for those students who have taken junior mathematics; first semester, four hours a week. Analytic mechanics. Peck's "Analytic Mechanics." — Professor HASBROUCK.

Second semester, four hours a week. Laboratory work. — Professor HASBROUCK.

Civil Engineering and Surveying.

Sophomore year, second semester, two exercises of two hours a week. Plain surveying with field work, including the use of the usual surveying instruments. Text-book and lectures. — Professor OSTRANDER.

Instruction in civil engineering will be given in two distinct courses of one year each, the courses alternating. They will be open to students of the junior and senior classes as indicated below. The course for 1906–07 will be for students in mathematics only. First semester, three hours' recitation and two hours' draughting a week. Stresses in roofs, bridges and graphic statics. Merriman and Jacoby's "Roofs and Bridges," Parts I. and II.

Second semester, four hours a week. Strength of materials and masonry construction. Merriman's "Mechanics of Materials." — Professor OSTRANDER.

The course of 1907–08 will be required of juniors and seniors taking the courses in mathematics and landscape gardening.

First semester, four hours a week. Hydraulics and sanitary engineering. Text-book and lectures. — Professor OSTRANDER.

Second semester, three hours' recitation or lectures and two hours' field work or draughting a week. Topographic and higher surveying, highway construction, the measurement of earth work, pavements and railroad construction. Text-book and lectures. — Professor OSTRANDER.

Drawing.

Junior year, first semester, two two-hour sessions a week for students in mathematics and landscape gardening; free-hand drawing.

Second semester, two two-hour sessions a week. Mechanical and topographic drawing.

Entomology.

The importance of a knowledge of insects in every department of life is recognized by placing an introductory course in this subject as a required study in the junior elective courses: (1) agriculture, (2) horticulture, (3) biology, (4) landscape gardening. For those who desire a further knowledge of it, because of its importance to their future occupations, a senior elective is offered, so shaped as to be of especial value for those who expect to take up agriculture, horticulture, landscape gardening, forestry or science teaching as life occupations.

Junior year, second semester, four exercises a week, of two hours each. Lectures, laboratory and field work; general consideration of insect structure and life histories; systematic study of the groups of insects, with particular reference to those of economic importance; methods for preventing or checking their ravages; insecticides and apparatus for their use; the collecting, mounting and naming of insects, and examination of the work of insects in the field and laboratory. — Professor H. T. Fernald.

Senior year, elective, open to those who have taken the junior entomology, first and second semesters, three laboratory exercises of two hours each, and one lecture, a week. Lectures, laboratory and field work; advanced morphology of insects; economic entomology; training in the determination of insects; use of literature on entomology; study of life histories; value and application of insecticides; thesis on insects most closely related to future occupation of the student. — Professors C. H. Fernald and H. T. Fernald.

Modern Languages.

French. — Course I.: required, four hours a week for both semesters of the freshman year. The special aim of this course is to enable the student to lay the foundation of an ability to read modern French fluently, special reference being had to scientific journals and treatises. The object of the grammar drill is to give not only instruction in the broader and more general topics, but also a thorough drill in the idiomatic peculiarities of the language, a thorough comprehension of which is held to be absolutely necessary to a correct and accurate translation. Great stress is laid upon the acquisition of a good vocabulary, and absolute accuracy in translation is insisted upon. The course is further strengthened by drill in pronunciation, exercises and

composition, and, in general, in whatever tends to increase interest, facility and ability in translation.

Course II. is given, upon demand, as a supplement to Course I., and is an elective requiring four hours a week for both semesters of senior year. Its aim is, primarily, to furnish by an additional year's training a greater practical efficiency in translation than can be attained merely by the completion of Course I.; and, secondarily, to equip the student with a general knowledge of scientific French literature. Constant advanced drill is furnished along the general lines of Course I., with the object of attaining such mastery of the language that it may be easily used as a tool in scientific pursuits and investigations of any nature. Students who have not attained a good rank in Course I. are not encouraged to elect Course II.

Though the main object of both courses is practical, a general attempt is constantly made, by the comparison of French and English and by occasional lectures on French life and customs, to interest the student in the study and better comprehension of the genesis of his own language, and to encourage a desire for a broad and general culture.

Spanish. — Given at present as an elective for four hours a week during both semesters of the year. This course is open as a regular study to seniors, and to freshmen who upon entering college have passed off French or German (Course I.), and also as an extra to any student in good and regular standing. It is offered in response to the recognized demand in Spanish-speaking countries for graduates of agricultural colleges who have made a specialty of agriculture, entomology, horticulture, engineering, etc. Students planning future fields of work in such countries are thus enabled to acquire sufficient facility in reading, writing and speaking the Spanish language to start them to the best advantage. The earlier work is based upon some such grammar as Marion and Garennes' "*Introducción á la Lengua Castellana.*" The course is strengthened by writing from dictation, and by the reading of books characteristic of Spanish life and customs.

German. — Course I.: required for both semesters of sophomore year, three hours a week first semester, three hours a week second semester. An understanding of the rudiments of grammar, facility in translation and an ability to pronounce the language and to understand simple spoken German are the main objects in view. — Assistant Professor NEAL.

Course II.: elective for both semesters of senior year, four hours a week. Special attention is given to the reading of Ger-

man, particularly to German of a scientific nature. Work is also required in prose composition throughout the year. Accuracy in pronunciation, the ability to understand German as spoken in the class room, and to converse within reasonable limits, are also features of this course. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Assistant Professor NEAL.

MILITARY SCIENCE.

In compliance with the provisions of an act of Congress of July 2, 1862, military instruction under a regular army officer, detailed for this purpose, is required of all able-bodied male students. Men are excused from attendance upon the exercises of this department only on a surgeon's certificate, given by a resident physician.

The object of such instruction is clearly to disseminate the elements of military knowledge throughout the country, that, in case of sudden emergency, a sufficient number of well-trained educated men may be found to command and properly to instruct volunteer troops. Military drill also has the object in view of giving the student physical exercise, teaching respect and obedience to those in authority without detracting from pride of manhood, and developing a military bearing and courtesy becoming in a citizen as in a soldier.

In order to further stimulate the study of military science in colleges, the War Department issued General Orders, No. 101, dated Washington, D. C., June 29, 1905, as follows: —

The reports of the regular inspections of the colleges and schools to which officers of the Army are detailed, in pursuance of law, as principals or instructors, will annually hereafter be submitted to the general staff for its critical examination, and the chief of staff will report to the Secretary of War, from the institutions which have maintained a high standard, the six institutions whose students have exhibited the greatest interest, application and proficiency in military training and knowledge. The President authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions, provided sufficient vacancies exist after caring for the graduates of the military academy at West Point and the successful competitors in the annual examination of enlisted men. . . .

By order of the Secretary of War,

ADNA R. CHAFFEE,
Lieutenant-General, Chief of Staff.

Course I.: out of doors, an exercise of one hour, three times a week, Mondays, Tuesdays and Thursdays; infantry drill by squad, company, and battalion; guard mounting, dress parade, inspection and review; artillery drill by detachment; target practice.

All drills are in the drill hall during the winter months and inclement weather.

Students assigned to the college band are given instruction and practice in band music and band evolutions, in place of drills and recitations.

Course II.: theoretical instruction for freshmen, one hour a week for both semesters, comprises recitations, "Infantry Drill Regulations," "Manual of Guard Duty and Firing Regulations for Small Arms;" "United States Service Manual."

Course III.: theoretical instruction for seniors for both semesters, one hour a week, embraces drill and army regulations; duties of sentinels and guard duty, elements of military science, preparation of necessary reports and returns pertaining to a company of infantry, and a thesis on some military subject; Wagner's "Elements of Military Science," "Field Service Regulations." — Captain Martin.

Synopsis of the Courses of Instruction.

[The figures indicate the number of exercises a week; light-faced type, recitation periods of one hour each; heavy-faced type, laboratory periods of two hours each.]

Freshman Year.

First Semester.

Language,	English,	1	
	French,	4	
Mathematics,	Algebra,	5	
Science,	Agriculture,	4	
	Botany, 2+1,	3	
Military,	Tactics,	1	
History,		2	
			— 20

Second Semester.

Language,	English,	4	
	French,	4	
Mathematics,	Geometry and trigonometry,	4	
Science,	Anatomy and physiology, half semester, Chemistry, half semester,	4	
	Botany, 1+1,	2	
History,		2	
			— 20

Sophomore Year.

First Semester.

Language,	English,	3
	German,	4
Physics,		4
Science,	Agriculture,	4
	Chemistry,	3
	Zoölogy, 1+1,	2
		— 20

Second Semester.

Language,	English,	4
	German,	3
Physics,		4
Surveying,		2
Science,	Agriculture, 2+1,	3
	Chemistry, 2+1,	3
	Horticulture,	3
		— 22

Junior Year.

First Semester.

Course in agriculture,	Agriculture, 3+1,	4
	Botany, 2+1,	3
	Chemistry,	3
	Economics,	4
	Horticulture,	3
	English,	4
		— 21
Course in horticulture,	Horticulture,	4
	Horticulture, 1+3,	4
	Botany, 2+1,	3
	Chemistry,	3
	Economics,	4
	English,	4
		— 22
Course in biology,	Zoölogy, 3+1,	4
	Botany, 2+1,	3
	Chemistry,	3
	Economics,	4
	Horticulture,	3
	English,	4
		— 21
Course in chemistry,	Chemistry,	4
	Agriculture, 3+1,	4
	Mathematics,	4
	Economics,	4
	English,	4
	Special subject,	2
		— 22

Course in mathematics,	Analytical geometry,	4	
	Engineering, 1+3,	4	
	Free-hand drawing,	2	
	Landscape gardening,	4	
	Economics,	4	
	English,	4	
		—	22
Course in landscape gardening,	Landscape gardening,	4	
	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Free-hand drawing,	2	
	Horticulture,	3	
	Economics,	4	
	English,	4	
		—	23

Second Semester.

Course in agriculture,	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Entomology,	4	
	Geology,	3	
		—	19
Course in horticulture,	Horticulture,	4	
	Botany, 2+1,	3	
	Chemistry,	4	
	Landscape gardening,	2	
	Entomology,	4	
	Geology,	3	
		—	20
Course in biology,	Entomology,	4	
	Zoölogy,	4	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Geology,	3	
		—	20
Course in chemistry,	Chemistry,	5	
	Agriculture, 2+1,	3	
	Mathematics,	4	
	Geology,	3	
	Special subject,	5	
		—	20
Course in mathematics,	Engineering,	4	
	Mathematics,	4	
	Mechanical drawing,	2	
	Landscape gardening,	4	
	Geology,	3	
		—	17

Course in landscape gardening,	Landscape gardening,	4	
	Botany, 2+1,	3	
	Mechanical drawing,	2	
	Engineering,	5	
	Entomology,	4	
	Geology,	3	
			— 21

SENIOR YEAR.

First Semester.

The following subjects are required in all courses: —

Bacteriology, half semester, 4, / Constitution of the United States, half semester, 4,	4	
Military science,	1	
		— 5

Second Semester.

Constitution of the United States,	4	
Military science,	1	
		— 5

From the following the student must elect three courses, closely correlated with his junior year course; only one course in language may be elected: —

Agriculture,	4	Physics,	4
Horticulture, 3+1,	4	Engineering,	4
Veterinary,	4	English,	4
Botany, 3+1,	4	French,	4
Landscape gardening, 3+1,	4	German,	4
Entomology, 3+1,	4	Spanish,	4
Chemistry, 3+1,	4	Latin,	4
Floriculture, 3+1,	4		

SHORT COURSES.

These courses are open to persons of both sexes. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. No entrance examination is required. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

I. Dairy Farming.

	Hours per Week.
Soils, tillage and methods of soil improvement; manures and fertilizers and their use; crops and rotations,	4
Breeds and breeding of dairy stock; judging to scale of points,	2
Fodders and feeding farm live stock,	1
Stable construction and sanitation,	1
Common diseases of stock; prevention and treatment,	1
Dairy products: their general characteristics; testing,	2
Chemical composition of milk and of special milk products,	1
Botany,	2
Horticulture,	3
Entomology,	3
Dairy practice, including testing, use of separators, butter making, preparation of certified and modified milk, and pasteurization,	4
Practice in horticulture,	1

Begins first Wednesday in January, and continues ten weeks.

II. Horticulture.

	Hours per Week.
Soils, tillage, manures, etc.,	4
Plant propagation and pruning,	3
General fruit growing,	3
Market gardening,	3
Botany,	4
Entomology,	3
Practice work in seed testing, seeding, grafting, budding, transplanting, judging fruit, etc.	

Begins first Wednesday in January, and continues ten weeks. This course will not be given unless at least eight men register for it.

III. Bee Culture.

	Total Hours.
The structure of bees, with special reference to their work (Prof. H. T. Fernald),	3
Flowers and fruits in their relations to bees (Professor Stone),	10
Honey crops, and how to grow them (Professor Brooks),	5
Bees and bee keepers' supplies (Professor Paige),	10
Work in the apiary, under direction of an expert,	20
Instruction by specialists,	4

This course begins the fourth Wednesday in May, and continues two weeks, but will not be given unless applied for by at least six students.

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables destroyed by fire in November, 1905, were stocked with the best breeds of horses, cattle, sheep and swine, and will be replaced by new buildings at as early a date as possible. The laboratory is provided with the latest forms of apparatus for mechanical analysis of soils and determination of their physical characteristics. Provision has been made in the laboratory for the study of seeds and crops and for germination trials. Power has been introduced into the laboratory, so that farm machinery may be operated for purposes of demonstration. The department has also a line of instruments for use in drainage and irrigation practicums. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution and the theory and practice of agriculture. The department has assigned to its use one lecture room with museum attached, and five rooms for laboratory and dairy purposes.

Horticulture.

For illustration of the science and the practice of horticulture the department possesses about one hundred acres devoted to orchards planted with all the leading old and all new varieties of apples, pears, peaches, plums, Japanese and American cherries, quinces, chestnuts, hickory nuts and walnuts; vineyards containing nearly two hundred named varieties of grapes, for sale, beside several hundred seedlings, and about an acre devoted to a commercial crop of a few market varieties; nurseries containing all kinds of fruit and ornamental trees, shrubs and plants, in all stages of growth, from the seed and cuttings to those ready for planting in the orchard or field; small fruit plantations containing valuable varieties, and showing the modern methods of training, pruning and cultivation; extensive greenhouses that contain not only valuable collections of specimen plants, representing types of the flora of the world, but also the most valuable economic plants, such as the orange, banana,

lemon, guava, pomegranate, sago palm, arrowroot, tapioca, ginger, pepper, tea, coffee, camphor, India rubber, Manila hemp, banyan tree, etc. All the common greenhouse and outdoor decorative plants are found, and small quantities of roses, carnations, chrysanthemums and other commercial flowering plants are grown, to illustrate the business of horticulture. All vegetable crops, now so largely grown under glass, are grown in limited quantities for purposes of instruction and for market.

For illustration in the work of landscape gardening, the grounds about the greenhouses, as well as that part of the grounds known as the Clark Park, are planted with a very large and complete collection of ornamental trees, shrubs and plants.

For forestry there are two large groves of trees of varying ages, from those of almost primeval growth to the youngest seedlings, besides several plantations of younger growth either natural or planted; and in the botanical museum there is a very complete collection of woods of Massachusetts.

The work in horticulture, floriculture and landscape gardening is now much better provided for than in the past, through the completion of the new Wilder Hall. This contains three class rooms, three student laboratories, a large drafting room and a library, besides offices, a museum and private laboratories. It is a substantial structure, three stories high, containing all the most modern appliances, and exemplifying the best ideas in college laboratory building. It is practically fireproof, being constructed of red brick, terra cotta and tile. The floors and the roof are of tile.

All kinds of pumps and other appliances for distributing insecticides and fungicides, as well as various modern tools and implements, are in constant use.

A small cold-storage room makes possible the keeping of the products beyond their natural season, and illustrates one of the most important adjuncts to the business of modern horticulture.

Chemistry.

This department has fourteen rooms, well adapted to their special uses. They are supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor has a seating capacity for seventy students. Immediately adjoining it are four smaller rooms, used for storing apparatus and preparing materials for the lecture table. The laboratory for beginners is a large room on the first floor, furnished with

forty working tables. Each table is provided with reagents and apparatus for independent work. A well-filled laboratory for advanced work is also provided on the first floor. A weighing room has six balances, and improved apparatus for determining densities of solids, liquids and gases. The apparatus includes, besides balances, a microscope, a spectroscope, a polariscope, a photometer, a barometer, and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milking products, fibres and other vegetable and animal products, and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished product.

Geology.

As a part of general culture, geology has a well-recognized importance; but more particularly as a part of the training of agriculturists it forms an important part of the curriculum of our agricultural colleges.

The equipment is ample. It consists of a complete educational series of rock-forming minerals and rocks, a large collection of the rocks of the State, student collections, charts, models and maps.

Zoölogy.

Zoölogical Laboratory. — A large, well-lighted room, situated in the old chapel building, is amply supplied with the best apparatus obtainable. The equipment includes compound and simple microscopes, dissecting instruments and trays, an incubator, paraffin bath, microtomes, etc., also a reference library, containing the current zoölogical journals and a good series of mounted slides for the microscope.

Zoölogical Lecture Room. — The lecture room is in south college, adjacent to the museum; its equipment includes, besides the museum specimens, the Leuckart series of charts, and many specially made charts as well; the Auzoux models, illustrative of human and comparative anatomy; and an electric stereopticon.

Museum of Zoölogy. — The museum is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as

fully as possible the fauna of the Commonwealth, and those types which show the evolution and the relationship of the members of the animal kingdom. The total number of specimens contained in the museum now exceeds eleven thousand. The museum is open to the public from 3.30 to 5.30 P.M. each week day.

Entomology.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glassware. One portion of the building is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over fifty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject. This is supplemented by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. As the laboratory is directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room fitted up for the analysis of insecticides and other chemico-entomological work; and a greenhouse, where plants infested by injurious insects are under continual observation and experimental treatment, — all these are available to the student. In addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large greenhouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for study of the attacks of injurious insects under natural conditions.

Veterinary Science.

The department has for its sole use a commodious and modern laboratory and hospital stable, erected in 1899. Both buildings are constructed in accordance with the latest ideas regarding

sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The laboratory building contains a large working laboratory for student use, and several small private laboratories for special work. In addition, there is a lecture hall, museum, demonstration room, photographing room and workshop. The hospital stable contains a pharmacy, operating hall, post-mortem and disinfecting room, besides a section for poultry, one for cats and dogs, and six sections, separated from each other, for the accommodation of horses, cattle, sheep, swine and other domestic animals.

The laboratory equipment consists of a dissecting Auzoux model of the horse, Auzoux models of the foot and the legs, showing the anatomy of the diseases of every part. There are skeletons of the horse, cow, sheep, dog and pig, and, in addition, a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams, which are made use of in connection with lectures and demonstrations.

The laboratories are supplied with the most modern high-power microscopes, microtomes, incubators and sterilizers, for the use of students taking the work in bacteriology and parasitology.

Botany.

The botanical department possesses a general laboratory, furnished with tables and benches for microscopical and physiological work, and with a dark closet for photographic purposes. There are forty compound microscopes, twenty-three dissecting microscopes, a micro-photographic and landscape camera and various accessories; also microtomes, paraffin baths, etc., for histological work; a large and useful collection of physiological apparatus for the study of photo-synthesis, respiration, metabolism, transpiration, heliotropism, geotropism, hydrotropism, galvanotropism, chemotropism, and other irritable phenomena connected with plants; a set of apparatus for the study of the mechanical constituents of the soil; a large and unique outfit of electrical appliances for the study of all phenomena related to electricity and plant growing; various devices for the study of mechanics of plant structure; numerous contrivances to determine the power exerted by living plant organisms; several types of self-registering auxanometers, used to measure the rate of

growth of plants; self-registering thermometers, and hygrometers for recording constant changes in conditions.

A small special laboratory for graduate students is equipped with microscopes and other apparatus and reagents for advanced work.

Botanical Lecture Room. — The botanical lecture room adjoining the laboratory is adapted for general work in morphology and flower analysis, with opportunity to use dissecting microscopes. It contains a movable chart system, arranged to display over three thousand figures relating to the structure and function of plants.

Mathematics, Physics and Engineering.

Surveying. — The department possesses a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by performing a required amount of field work. Among the larger instruments are two plain compasses, railroad compass with telescope, surveyor's transit, two engineer's transits with vertical arc and level, solar compass, omnimeter with verniers reading to ten seconds, adapted to geodetic work, Queen plane table, two wye levels, dumpy level, builder's level, sextant, hand level, and a large assortment of levelling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, pantograph, parallel rule, etc., are available. A cement-testing outfit has recently been added, for use in the course in strength of materials.

Physics. — Among the apparatus in use for general instruction in general physical processes may be found a set of United States standard weights and measures, precision balances, spherometer, vernier calipers, etc.; in mechanics, apparatus to illustrate the laws of falling bodies, systems of pulleys and levers, motion on an incline plane, and the phenomena connected with the mechanics of liquids and gases. The usual apparatus for lecture illustration in heat, light and sound are also in the possession of the department. In electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, among which may be enumerated a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, Mascart quadrant electrometer, Siemens electro-dynamometer, as well as reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistance.

Military Science.

In addition to a large campus, suitable for battalion drill, the military department possesses a special building in which there is a drill room 60 by 135 feet, an armory, a recitation room, an office for the commandant, and a field gun and gallery practice room. The building also has a large bathroom immediately adjoining the armory.

In a plot of ground west of the college buildings there is a rifle range, marked for practice at distances of 100 and 200 yards. The range is furnished with a revolving target suitably protected by earthworks. The national government supplies, for the use of the department, arms and equipments; the new Krag Jorgensen rifle, with complete accoutrements and ammunition.

The State supplies instruments for the college band.

Students are held responsible for all articles of public property while in their possession.

The Chapel-Library Building.

One of the most attractive and commodious buildings belonging to the college is the chapel-library. It has a commanding position, approximately in the centre of the group of buildings adjoining the campus. The chapel occupies the entire second story. A large room, capable of seating about four hundred, is used for daily prayers, Sunday services, the various commencement exercises, and not infrequently for lectures or social gatherings. The room has an excellent pipe organ. Two adjoining rooms are used for small religious gatherings, and meetings of the class teachers and of the faculty. The rooms can be thrown open so as to become a part of the main audience hall.

The entire lower story is given over to the library. This library is available for reference or investigation, and is open daily, except on Sundays, from 8 A.M. to 5 P.M. and from 6.30 to 8.30 P.M. It is open on Sundays from 10 A.M. to 1 P.M. The volumes at present number 27,690. The library contains carefully selected books in the departments of agriculture, horticulture, botany, entomology and other natural sciences. Sociology, economics, history, literature, the fine arts and the useful arts are well represented. Constant additions will be made to secure the latest and best works in the several departments of learning.

Dining Hall.

A colonial dining hall, built of brick and equipped with all modern conveniences, was completed and opened February, 1903, for the accommodation of students. A committee composed of two members of the faculty, two members of the student body, and the steward, manages the affairs of the dining hall.

The hall contains a number of suites of rooms which may be secured for occupancy by young women attending any of the departments of the college.

The Heating, Lighting and Power Plant.

This plant is located in the ravine, near the chemical laboratory. It is equipped with two large boilers, an engine and an electric generator. Here steam is generated which heats the college buildings on the west side of the public highway, extending from the dining hall to the veterinary laboratory, and the horticultural building and botanic museum on the east side. Here also is produced the electricity which lights all the buildings and the grounds of the college. Electric power is also generated which is used to drive the machinery in the dairy and in the barn. Connected with the plant is a machine shop in which much work is done for the college. The plant affords opportunity for students in mechanical and electrical engineering to observe the modern utilization of steam and electricity.

EXPENSES.

Tuition. — Tuition is free to citizens of the United States. Citizens of Massachusetts, however, in accordance with an act of the Legislature, must make application to the Senator of the district in which they live for a free scholarship that covers the charge for tuition. Blank forms for such application may be obtained from the president of the college.

Rooms. — It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere. For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven

feet two inches by eight feet five inches. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. All rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

Board. — Board at the new dining hall has been $3.25 per week; in private families, $4 to $5. The college does not guarantee to keep the price of board at any particular figure.

Incidental Expenses. — The military suit must be obtained immediately upon entering college, and used in the drill exercises prescribed. The following fees, to be paid in advance, are applied towards the maintenance of the several laboratories: chemical, $15 per semester used; zoölogical, $2 per semester used sophomore year, other classes $4 per semester; entomological, $3 per semester used. The fee for use of the botanical laboratory for one period of two hours during each week is $1 per semester; other periods will be charged for proportionally. Some expense is also incurred for text-books. In exceptional cases incidental expenses necessitate additional charges.

Room rent, in advance,	$15 00	$45 00
Board, $3.25 to $4 per week,	117 00	144 00
Fuel,	12 00	12 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
Miscellaneous,	41 00	45 00
	$220 50	$300 00

In addition to the above expenses, $120 tuition is charged to foreigners.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator from his district for a scholarship. Blank forms of application will be furnished by the president.

THE STATE LABOR FUND.

The object of this fund, five thousand dollars appropriated annually by the State, is to assist those Massachusetts students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Frank A. Waugh, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

ENDOWED LABOR FUND.

There is available also the income of five thousand dollars, the gift of a generous friend of the college, which will be used in payment for labor of deserving students needing assistance.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Notwithstanding the death of Mr. Flint, these prizes will be continued under the name of the Flint prizes.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

The Hills prizes of thirty-five dollars, given by the late Henry F. Hills of Amherst, will this year be awarded to members of the senior class as follows: fifteen dollars for the best general herbarium; ten dollars for the best collection of Massachusetts trees and shrubs; and ten dollars for the best collection of Massachusetts woods.

J. D. W. French Prize.

Offered by the Bay State Agricultural Society to the members of the senior class for the best essay on forestry. Twenty-five dollars, to be called the J. D. W. French prize, in honor of the late J. D. W. French, formerly a trustee of the college, and one of the very earliest movers in favor of improved forestry management in New England.

Western Alumni Prize.

Twenty-five dollars, to be awarded at the end of sophomore year to that member of the sophomore class who during his two years in college has shown the greatest improvement in scholarship, character and example. Offered by the Western Alumni Association.

Forestry Prize.

Two prizes, fifteen and ten dollars, offered to those members of the senior and junior classes who prepare the best essays on the management of the farm woodlot. Given by an anonymous friend.

Winter Course Prizes.

The dairy prizes, given by the Massachusetts Society for Promoting Agriculture, to members of the short winter course. Two sets of prizes are offered: the first set consists of three prizes of fifty, thirty and twenty dollars, respectively, given for general excellence in all branches of the course as offered; the second set consists of three prizes of twenty-five, fifteen and ten dollars, respectively, for excellence in the making of butter.

Award of Prizes, 1906.

Grinnell Agricultural Prizes (*Senior*). — First prize, Edwin Hobart Scott; second prize, Edwin Francis Gaskill.

Hills Botanical Prizes (*Senior*). — Best collection of Massachusetts trees and shrubs, Daniel Henry Carey; best collection of Massachusetts woods, James Edward Martin.

Flint Oratorical Prizes (*Junior*). — First prize, Wayland Fairbanks Chace; second prize, Charles Morton Parker.

Burnham Essay Prizes (*Sophomore*). — First prize, Danforth Parker Miller; second prize, Herbert Linwood White; third prize, Orton Loring Clark; honorable mention, Roland Hale Verbeck.

Burnham Declamation Prizes (*Freshman*). — First prize, Oscar Christopher Bartlett; second prize, Paul Edgar Alger.

Western Alumni Improvement Prize (*Sophomore*). — John Daniel.

Military Honors (*Senior*). — The following cadets were reported to the Adjutant-General, U. S. A., and to the Adjutant-General of Massachusetts, as having shown special aptitude for military service: Herman Augustus Suhlke, George Talbot French, Stanley Sawyer Rogers, Benjamin Strain.

Dairy Prizes (*Winter Course Students*). — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, Helen Holmes; second prize, Nelson Lansing Martin, Jr.; third prize, John Anson Newhall.

Massachusetts Society for Promoting Agriculture: for highest

scoring butter, first prize, Francis Curry; second prize, Nelson Lansing Martin, Jr.; third prize divided between Leslie Rogers Corbin and John Anson Newhall.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, Lester Gifford Heath; second prize, Frank David McKenzie; third prize, John Wood Leonard, Jr.; fourth prize, Henry Weston Trask.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one-half ton Stockbridge fertilizer, Helen Holmes.

Special prize, given by B. von Herff of New York, for best knowledge of the use of fertilizers on grass lands, Helen Holmes.

RELIGIOUS SERVICES.

Chapel services are held every week day at 8 A.M. Further opportunities for moral and religious culture are afforded by Bible classes, and by a religious meeting Thursday evening, both under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Millers Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of four hundred acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

Receipts and Disbursements, Dec. 21, 1905, to Nov. 30, 1906.

	Received.	Paid.
State Treasurer, Morrill fund,	$16,666 66[1]	
Endowment fund: —		
United States grant,	3,650 00	
State grant,	3,313 32	
Annual Appropriation.		
Maintenance,	5,000 00	
Instruction,	13,000 00	
Scholarship,	15,000 00	
Labor,	5,000 00	$4,492 59
Heating and lighting maintenance,	500 00	500 00
Dining hall maintenance,	500 00	500 00
Veterinary laboratory maintenance,	1,000 00	794 08
Library income: —		
Amherst Savings Bank,	115 86	1,819 57
Bonds,	400 00	
Burnham emergency fund income: —		
Northampton Institution for Savings,	75 00	130 00
Massachusetts Agricultural College, interest,	75 00	
Agricultural laboratory fees,	21 40	215 33
Botanical laboratory fees,	364 19	398 51
Chemical laboratory fees,	687 62	721 07
Entomological laboratory fees,	49 50	145 03
Landscape gardening fees,	107 90	54 30
Zoölogical laboratory fees,	139 71	133 79
Agricultural department (including dairy school),	908 51	2,612 87
Farm department (produce, live stock, labor, etc.),	7,085 93	12,792 89
Horticultural department (market gardening, nursery, etc.),	6,995 70	9,005 41
Expense (rents, interest, etc.),	1,855 30	6,616 45
Amounts carried forward,	$82,511 60	$40,931 89

[1] Annual appropriation from the United States, received from State Treasurer.

	Received.	Paid.
Amounts brought forward,	$82,511 60	$40,931 89
Term bill (tuition, students' rents, text-books),	4,691 94	2,112 95
Heating and lighting department,	2,309 50	10,055 00
Salaries,		32,768 52
Extra instruction,		160 00
Band,		73 38
Advertising,		616 05
Furniture,		593 62
Tools, lumber account,		1 32
Fire apparatus,		18 00
Insurance,	317 25	5,615 16
Dining hall,	12,973 93	15,749 66
Excess of disbursements over receipts,	5,892 33	
	$108,696 55	$108,696 55

Cash Account.

Dr.

Cash on hand Dec. 20, 1905,	$22,413 62	
Excess of disbursements over receipts, Nov. 30, 1906,	5,892 33	
		$16,521 29

Cr.

Cash on hand Nov. 30, 1906,		$16,521 29

Inventory — Real Estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory and insectary,	6,000 00	
Veterinary laboratory and stable,	22,500 00	
Amounts carried forward,	$133,075 00	$44,350 00

Amounts brought forward,	$133,075 00	$44,350 00
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn, dairy school and wagon house (unfinished),	34,000 00	
Graves house and barn,	1,500 00	
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Wilder Hall,	37,000 00	
Clark Hall (unfinished),	45,000 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		331,775 00
		$376,125 00

EQUIPMENT.

Botanical department,	$4,200 00	
Botanical laboratory,	3,500 00	
Horticultural department,	18,091 49	
Farm,	19,683 79	
Chemical laboratory,	1,332 00	
Entomological laboratory,	15,450 00	
Zoölogical museum,	6,150 00	
Zoölogical laboratory,	3,300 00	
Veterinary laboratory,	6,000 00	
Physics and mathematics,	4,000 00	
Agricultural department,	2,500 00	
Agricultural laboratory,	1,700 00	
Library,	28,000 00	
Fire apparatus,	300 00	
Band,	500 00	
Furniture,	2,000 00	
Text-books,	450 00	
Tools, lumber and supplies,	834 25	
Heating and lighting,	61,263 80	
Dining hall,	5,000 00	
		$184,255 33

Balance Sheet, Nov. 30, 1906, not including Real Estate and Equipment.

Assets.

Due farm from sundry persons,	$266 10	
Due horticultural department, sundry persons,	707 51	
Due from students for text-books,	553 53	
Due from students for room rent,	347 34	
Due from students for heat and light,	872 83	
Due from students for laboratory fees,	759 32	
Due from students for board,	793 10	
Due from State of Massachusetts (Wright & Potter Printing Company's bill),	320 35	
Notes,	200 00	
Cash on hand,	16,521 29	
		$21,341 37

Liabilities.

Due labor fund,	$1,308 45	
Due veterinary laboratory,	359 42	
Due insurance,	11,897 20	
Due Burnham emergency fund, note,	3,000 00	
Due excess of assets over liabilities,	4,776 30	
		$21,341 37

Funds.

Endowment Fund.

	Amount.	Income.
United States grant,	$219,000 00	$3,650 00
Commonwealth grant,	142,000 00	3,313 00
		$6,963 32

This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Burnham Emergency Fund.

	Amount.	Income.
Northampton Institution for Savings,	$2,000 00	$75 00
Massachusetts Agricultural College note,	3,000 00	75 00
	$5,000 00	$150 00

Library Fund.

	Amount.	Income.	Market Value.
Five bonds Lake Shore & Michigan Southern 4s,	$5,000 00	$200 00	par.
Five bonds New York Central & Hudson River Railroad,	5,000 00	200 00	par.
Amherst Savings Bank,	367 77	7 34	
Interest from Amherst Savings Bank, received Jan. 1, 1906,		108 52	
	$10,367 77	$515 86	

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

	Amount.	Income.	Market Value.
Two bonds American Telephone and Telegraph 4s,	$2,000 00	$80 00	93
One bond New York Central debenture 4s,	1,000 00	40 00	par.
Two bonds Lake Shore & Michigan Southern 4s,	2,000 00	80 00	par.
	$5,000 00	$200 00	
Unexpended balance Jan. 1, 1906,		220 21	
		$420 21	
Paid for labor,		206 43	
Cash on hand,		$213 78	

Hills Fund.

	Amount.	Income.	Market Value.
Northampton Institution for Savings,	$2,180 00	$81 75	
One bond American Telephone and Telegraph Company 4s,	1,000 00	40 00	93
Three American Telephone notes, 5 per cent.,	3,000 00	150 00	par.
One bond New York Central debenture 4s,	1,000 00	40 00	par.
One bond New York Central & Lake Shore $3\frac{1}{2}$s,	1,000 00	35 00	89
Boston & Albany Railroad stock,	362 00	31 68	240
	$8,542 00		
Unexpended balance Jan. 1, 1906,		686 11	
		$1,064 54	
Paid botanical and horticultural departments,		124 60	
Cash on hand,		$939 94	

Mary Robinson Scholarship Fund.

	Amount.	Income.	Market Value.
Northampton Institution for Savings,	$820 00	$30 75	
Boston & Albany Railroad stock,	38 00	3 32	240
	$858 00	$34 07	
Paid deficit Jan. 1, 1906,		4 74	
Cash on hand,		$29 33	

Whiting Street Scholarship Fund.

	Amount.	Income.	Market Value.
One bond New York Central debenture 4s, .	$1,000 00	$40 00	par.
Amherst Savings Bank, ...	271 64	5 20	
Unexpended balance Jan. 1, 1906, . .		17 16	
	$1,271 64	$62 36	
Paid cash, scholarship, ...		20 00	
Cash on hand, ...		$42 36	

Gassett Scholarship Fund.

	Amount.	Income.	Market Value.
One bond New York Central debenture 4s, .	$1,000 00	$40 00	par.
Amherst Savings Bank, ...	11 64		
Unexpended balance Jan. 1, 1906, . .		20 00	
	$1,011 64	$60 00	
Paid cash, scholarship, ...		20 00	
Cash on hand, ...		$40 00	

Grinnell Prize Fund.

	Amount.	Income.	Market Value.
Ten shares New York Central & Hudson River Railroad stock, ...	$1,000 00	$50 00	132½
Cash received for sale of rights, . . .		62 50	
Unexpended balance Jan. 1, 1906, . .		66 24	
	$1,000 00	$178 74	
Paid cash for prizes, ...		50 00	
Cash on hand, ...		$128 74	

Massachusetts Agricultural College.

	Amount.	Income.	Market Value
One share New York Central & Hudson River Railroad stock, ...	$100 00	$5 00	132½
Cash received from sale of rights, . .		11 75	
Unexpended balance Jan. 1, 1906, . .		5 00	
	$100 00		
Cash on hand, ...		$21 75	

Summary of Cash on Hand to the Credit of Special Funds.

Endowed labor fund,	$213 78	
Hills fund,	939 94	
Mary Robinson fund,	29 33	
Whiting Street fund,	42 36	
Gassett scholarship fund,	40 00	
Grinnell prize fund,	128 74	
Investment,	21 75	
		$1,415 90

I hereby certify that I have this day examined the Massachusetts Agricultural College accounts, as reported by the treasurer, George F. Mills, for the eleven months, Dec. 21, 1905, to Nov. 30, 1906. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

AMHERST, Dec. 14, 1906.

GIFTS.

BOOKS DONATED BETTER FARMING SPECIAL LIBRARY.

By AMERICAN SHEEP BREEDERS' PRESS: The Domestic Sheep, — Henry Stewart.

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Doubleday, Page & Co.: How to make School Gardens, — Hemenway.

S. T. Maynard: Landscape Gardening applied to Home Decoration, — Maynard.

From B. Von Herff, German Kali Works, New York: one ton kainit, or money value, as prize in dairy school.

Society for the Promotion of Agriculture: prizes offered in dairy school as follows: For butter: first, $25; second, $15; third, $10. For best work during the entire course: first, $50; second, $30; third, $20. For excellence in stock judging: first, $10; second, $7.50; third, $5; fourth, $2.50.

W. H. Bowker & Co.: one-half ton Stockbridge fertilizer, as prize in dairy school.

William S. Myers, New York: two thousand pounds nitrate of soda.

B. Von Herff, New York: one ton each high-grade sulfate of potash, low-grade sulfate of potash, muriate of potash.

Rockland Rockport Lime Company, Boston: one one-hundred-pound bag agricultural lime (shipped to Falmouth for experiment with cranberries); one bag R-R agricultural lime; one barrel pine cone hydrated lime.

H. J. Baker & Co., New York: tartar pomace, nitrogenous chalk, beet refuse compound and kalksalpeter, for experimental purposes.

The Dow Chemical Company, Midland, Mich.: one pound sodium benzoate, for experimental purposes.

Peter Henderson & Co., New York: four pounds Queen potatoes; four pounds Improved Green Mountain potatoes; four pounds Bliss' Red Triumph potatoes.

From Michigan Seed Company, Bay City, Mich.: Improved Early Rose, Michigan, New Wonderful, and Rural New Yorker potatoes.

W. Atlee Burpee, Philadelphia: Uncle Gideon's Quick Lunch potatoes.

George G. Schroeder, 1310 G Street, N. W., Washington, D. C.: publication, Egg Production and Preserving.

General Machinery and Supply Company, Chicago, Ill.: hand-power shearing machine.

Loans.

Empire Cream Separator Company, Bloomfield, N. J.: one Empire Separator No. 2.

The Sharples Separator Company, West Chester, Pa.: one Tubular Hand Separator No. 3; one Tubular Hand Separator No. 4; one Tubular Hand Separator No. 10.

De Laval Separator Company, 74 Cortlandt Street, New York, N. Y.: one Acme Turbine Separator; one Baby No. 2 Separator; one Alpha Daisy Separator.

D. H. Burrell & Co., Little Falls, N. Y.: one Simplex Hand Separator No. 2; one Simplex Turbine Separator No. 2½; one 10-bottle "Facile" Hand Tester; one 4-bottle "Facile, Jr.," Tester; one 24-bottle "Facile" Turbine Tester.

Vermont Farm Machine Company, Bellows Falls, Vt.: one Separator No. 7; one Separator No. 5; one No. 2½ Steam Turbine Separator; one Agos steam Babcock Tester; one 10-bottle Hand Tester.

Dairymen's Supply Company, Philadelphia, Pa.: Steam Turbine Bottle Washer.

Stoddard Manufacturing Company, Rutland, Vt.: one 24-bottle Wizard Turbine Tester.

FARM REPORT.

The work of the past year has been interrupted greatly by the loss of the farm barn, which was burned Nov. 16, 1905; and the housing of the live stock has in most cases caused a hardship, animals having to be kept in different buildings somewhat removed from each other, and where feed had to be drawn daily. Even to put these buildings in shape to keep the stock required an outlay for lumber and labor, thus materially increasing the expense.

During the fall of 1905 preparations were made for increasing our acreage in crops for 1906; accordingly, a considerable amount of land was turned over. This had to be handled, consequently it was decided that about 34 acres of corn should be planted, and a large part of the land seeded to grass. About 22 acres of the field was seeded in July, which resulted in a fine stand of grass. We wish to emphasize the importance of the selection of the seed; only the very best seed is used on the college farm. One of Professor Brooks's requirements in purchasing the seed is that it shall have been tested, thus selecting only that of high germinating power. This means a little extra cost per pound, but experience seems to warrant a fourfold result.

Corn.

Three varieties of corn were obtained from Minnesota for the main corn crop, namely; Rustlers White Dent, Pride of the North, and University of Minnesota No. 13. These were especially bred, and are being grown in latitudes farther north than is the State of Massachusetts. The prime object in going so far north for seed corn was to get something that would never fail to mature. The result this year seems to indicate that one of these varieties chosen, the Rustlers White Dent, is going to make good. The yield this year was an average of 150 bushels of mature ears per acre; the ears are of good length and size, well filled to the tip with mature corn.

The two varieties Pride of the North and University of Minnesota No. 13 did not do as well, giving a much lighter yield of shorter ears, and not as well filled. The stover from each variety was of good quality.

Ten acres were planted to Leaming corn for silage, but, owing to unavoidable circumstances, the new silos were not built in time to ensile all the crop. A part of the crop, however, was harvested into a temporary silo, and is of excellent quality. The balance, about 5 acres, was allowed to mature the grain. From this about 840 bushels of ears were picked. While all this corn was not as hard as one would wish for, there was a fair amount of well-matured corn.

Potatoes.

Seven acres of field and 3½ acres of newly reclaimed stump land were planted to this crop.

On those grown on the field quite an extensive experiment with different kinds of insecticides and fungicides was arranged and carried out. Through the generosity of the Bowker Fertilizer Company the following materials were donated for this experiment, namely, dust Bordeaux, copper phosphate and 1–2–3. Dust Bordeaux is a fungicide to take the place of wet Bordeaux, copper phosphate an insecticide and fungicide, and 1–2–3 an insecticide and fungicide. The field was systematically laid out, so that comparisons between this and wet Bordeaux could be made. Two check rows between each kind were left. The materials all did very well, and there was not enough difference between them to warrant a full report at this time.

The results obtained on the reclaimed land in the Durfee pasture were beyond expectations: 1,057 bushels of marketable potatoes and 50 bushels of small potatoes were harvested from 3½ acres. One and one-half acres of this land was cleared of stumps in the fall of 1905, and plowed; the remaining 2 acres, in the spring of 1906. From our experience we have found that a liberal use of dynamite lessens the expense materially. On the 5½ acres cleared the past two years, the cost of labor for getting out and piling the stumps has been $11 per acre. To this add $8.15 per acre for dynamite, and we have the cost per acre of preparing land ready for the plow, $19.15.

Experiments with Nitrate of Soda, High-grade Sulfate of Potash and Phosphatic Slag on Grasses.

On one of the fields of the campus plots of one-half acre were laid out, and fertilizers were applied as shown in the following table, together with the yields of the hay and rowen for the seasons of 1905 and 1906. The methods of applying the fertilizer are to spread broadcast with a Stevens' fertilizer spreader in the spring at about the time that the grass is well started.

A very interesting thing about the experiment is the behavior of the plots during the season of 1905, when we had an abundance of rainfall during the first part of the season for the first crop, and very little rainfall for the rowen. These conditions were nearly reversed for the season of 1906.

It should be said that the sod in these plots is almost entirely made up of grasses, herd's grass prevailing.

Experiments with Fertilizers on Permanent Mowings (Pounds per Acre.)

Plot.	Phosphatic Slag.	Nitrate of Soda.	High-grade Sulfate of Potash.	1905.		1906.	
				Hay.	Rowen.	Hay.	Rowen.
0,	–	–	–	3,580	168	2,900	760
1,	500	150	150	5,943	358	6,004	2,100
2,	500	200	150	9,696	510	6,116	2,280
3,	500	250	150	12,300	300	6,680	2,570

College Farm Crops, 1906.

Crops.	Acres.	Total Product.		Cost.		Value.	Profit.
		Bushels.	Tons.	Manures and Fertilizers.[1]	Labor and Seed.		
Mangels,	$\frac{1}{3}$	–	$3\frac{3}{4}$	$2 00	$15 20	$22 50	$5 30
Carrots,	$\frac{1}{3}$	250	–	2 00	40 50	62 50	20 00
Pop corn,	$3\frac{1}{3}$	227[2]	5[3]	3 00	60 40	239 50	176 10
Squashes,	2	–	20	14 00	55 00	300 00	231 00
Ensilage and field corn,	$34\frac{1}{3}$	3,793[2]	94[3]	265 46	871 10	2,022 00	1,191 00
	–	–	74[4]	–	–	–	–
Winter rye,	$\frac{1}{3}$	–	$1\frac{1}{4}$	3 00	10 00	20 00	7 00
Hay and rowen,	71	–	300[5]	98 09	1,125 00	3,000 00	1,776 91
Potatoes: —							
Large,	–	2,303	–	–	–	–	–
Small,	$10\frac{1}{2}$	200	–	117 90	727 80	1,313 60	467 96
Onions,	3	817.5	–	113 58	197 78	347 59	26 23

[1] Three-fourths value of fertilizer, one-half value of manure.
[2] Corn on the ear.
[3] Stover.
[4] Silage.
[5] In part estimated.

Manures and Fertilizers for the Several Crops per Acre.

	Squash Field.	Squash Pasture.	Pop Corn Pasture.	Pop Corn Field.	Corn, Rustler's White Dent.	Corn, Yellow.	Corn, Leaming.	Corn, University of Minnesota No. 13.	Corn, Pride of the North.	Calico Corn.	Mangels.	Carrots.	Potatoes.	Corn, Leaming.	Onions.
Manure (cords), ...	3	–	–	4	–	–	4	–	–	3	3	3	–	5	–
Nitrate of soda (pounds), .	–	–	–	–	100	–	–	100	100	–	–	200	250	–	233
High-grade sulfate of potash (pounds), ...	–	–	–	–	100	–	–	100	100	–	–	–	250	–	350
Phosphatic slag (pounds), .	–	–	–	–	300	–	–	300	200	–	–	600	400	–	800
Lime (pounds), . . .	–	–	–	–	2,000	–	–	2,000	2,000	–	–	–	–	–	1,000
Muriate of potash (pounds),	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dried blood (pounds), . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	330
Tankage (pounds), . .	–	–	–	–	–	–	–	–	–	–	–	–	80	–	400
Acid phosphate (pounds), .	–	–	–	–	–	–	–	–	–	–	–	–	200	–	600
Ashes and waste from barn ruins (cords), ...	–	5	–	–	–	5	–	–	–	–	–	–	–	–	–

Live Stock.

The kinds and numbers of the several classes of live stock are shown below: —

Horses. — French Coach, 3 stallions, 4 mares, 2 filleys; Percheron, 1 stallion; Percheron, three-fourths blood, 1 stallion, 2 mares, 2 filleys; German Coach, 1 mare; French Coach, half blood, 2 mares, 4 work horses.

Neat Cattle. — Jersey, 2 calves, 1 yearling heifer, 2 cows; Ayrshire, 2 bulls, 3 calves, 2 yearlings, 7 cows; Holstein-Friesian, 7 cows, 2 calves.

Swine. — Berkshire, 7 boars, 2 sows, 1 pig; Yorkshire, 1 boar, 4 sows, 34 shoats.

The stock is in a healthy condition generally. We have lost one of a pair of team horses the past year, due to colic causing ruptured stomach.

Swine.

We have made a practice of keeping an accurate account of foods consumed by our growing pigs, and a brief report of the results of feeding a mixed lot of Berkshire, Yorkshire and Chester White pigs, 42 in all, will be of interest. This lot of pigs would not average better than those of most farmers who make a business of raising good hogs, and it cannot be said that they were selected for the purpose of making a show, for there were mixed in some three or four very small ones.

They were weaned and turned into the hog lot May 18, and allowed the run of a shed for shelter from cold and storms. The following table gives the amount of food, etc., consumed from May 18 to September 9, when they were shipped to Brighton market: —

Date.	Food.	Amount.	Rate per 100.	Total Value.
May 18 to Sept. 9.	Corn meal,	9,050 lbs.	$1 20	$108 60
	Middlings,	212 lbs.	1 20	2 54
	Skim milk,	30,994 lbs.	20	61 98
	Molasses,	68.8 gal.	12½ per gal	8 60
	Low-grade flour,	5,068 lbs.		65 88
Total cost of feed,				$247 60
To this add the value of 42 pigs, at $2.50,				105 00
Total cost of pigs,				$352 60

September 9, by cash from 42 pigs, $500, leaving a profit of $147.40, or $3.50 each.

No account was made of labor and manure, for it was estimated that the value of one offset the value of the other.

The flour ration was fed mostly during the first half of the period, corn meal being substituted in the latter half, or fattening period.

As has been said, this feeding was not planned for an experiment. We simply kept account of what was fed, the chief aim being to grow the pigs as fast as possible, and not waste feed.

The Farm Finances.

The cash receipts for the year are $7,013.46, and there is due on account of sales made during the year over and above bills payable the sum of $266.10; this, added to the cash receipts, makes a total of $7,279.56.

The inventory at the present time is $19,953.79, — an increase of $7,022.61 over last year's inventory; this increase of $7,022.61, added to cash receipts, makes a total of $14,302.16: from this deduct the total expenses for the year, or $12,594.08, and we have a balance of $1,708.08 to credit to the farm. There is also another credit due the farm, of work reclaiming 5½ acres of the Durfee pasture, at $50 per acre, making the total credit to the farm $1,983.08. In addition to the above total of expenses. there has been an expenditure of $2,910.93 from insurance funds, for the purchase of new equipment. The final net result of the farm operation is a loss, represented by the difference between the above apparent credit of $1,953.08 and this expenditure of $2,910.93, or $957.85.

The cash received during the year has been derived from the following sources: for milk and cream, $1,722.10; cattle, $214.66; horses, $308; swine, $205.95; sheep, $232.35; hay, $232.68; potatoes, $1,266.51; labor, $1,189.09; credit on bills charged to insurance, $599.40; sundries, $1,030.63.

E. H. FORRISTALL,
Superintendent.

MILITARY DEPARTMENT.

President KENYON L. BUTTERFIELD, *Massachusetts Agricultural College.*

SIR: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 20, 1906.

I have been in charge of the department of military science and tactics since September, 1905, under Special Order, No. 195, War Department, dated Washington, D. C., Aug. 23, 1905. The instruction has been both theoretical and practical, and conducted in compliance with college regulations and War Department orders.

Under the provisions of General Orders, No. 101, War Department, 1905, this instruction is graded, in respect to the military course, as of the second class, "B," requiring the following minimum of exercises, viz.: —

At every institution of Class B, at which a professor of military science and tactics is detailed, it shall be provided in its regular schedule of studies that at least three hours per week for two years, or the equivalent thereof, shall be assigned for instruction in the military department, not less than two-thirds of the total time to be devoted to practical drill, including guard mounting and other military ceremonies, and the remainder to theoretical instruction.

The character of instruction will vary according to the nature of the institutions and the facilities afforded; but instruction of classes A, B, and C shall include practical instruction in the following subjects: —

Infantry drill regulations.

Field service regulations.

Manual of guard duty.

Firing regulations for small arms.

Theoretical instruction shall include the portions of the above subjects covered by the practical instruction, and may be supplemented by lectures.

The above requirements of the War Department have been strictly complied with, and additional drills have been given in "Butts' Manual of Physical Drills" and in artillery drill. Only seniors and freshmen have been required to take theoretical instruction, each class once per week.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.: —

Monday, recitation of seniors, 5 P.M.; drill, 3.45 P.M.

Tuesdays, the same practical instruction as for Mondays.

Thursdays, drill at 3.45 P.M.; recitation of freshmen, 2.30 P.M.

Saturdays, inspection of dormitories, including students' rooms, 8.30 A.M.; instruction in guard duty and duties of sentinels, 8.15 to 10.15 A.M. The latter exercise is required only of those students who have incurred demerits in the military department, such as unauthorized absence from drill or inspection, or room not in proper order.

Drills are both in close and extended order; battalion drills are usually preceded by parade and review.

The order of drill commences with small squads in the school of the soldier, and proceeds step by step, with and without arms, until the freshmen become proficient, when they are assigned to the companies, after which the exercises include all movements in company and battalion drill.

The drills are varied as much as consistent with official regulations, to embrace gallery practice (firing indoors at an iron target with a reduced charge of powder, two grains) and "Butts' Manual of Physical Drill," the latter in the drill hall during the winter months, and when the weather is too inclement to drill out of doors.

During the visit of the inspector sent here last May by the War Department a thorough inspection was made of the target range, and it was decided by him to be unsafe, in which opinion I thoroughly concurred. As a result, the range was immediately condemned; and, as a consequence, only 70 students received instruction in target practice on the field range last year. The rifles used were the old Springfield cadet rifles, and, as they were practically worn out and obsolete, the progress made was poor. This is a subject of the greatest importance, and much more time could be well devoted to it. To become a good marksman requires a careful study of the mechanism of the rifle; frequent practice upon the rifle range under various conditions of weather, and daily practice for a few minutes each day in the sighting;

pointing and aiming drills for at least a month before going to the range; also gallery practice.

If target practice is to be continued, I strongly recommend that a new range be built, with at least three targets; and, if it is possible, that some provision be made by the State whereby tentage and camp equipage be provided which would enable the whole student body to go into camp for one week in each college year, the time to be given to instruction in guard and outpost duty, target practice, construction of shelter trenches, etc.

Recently all of the old Springfield rifles have been returned to the War Department, and new Krag Jorgensen rifles have been sent to replace them. This rifle is modern and up to date, and with it the very best of target practice can be accomplished.

The War department recently decided to call in all artillery material that was not obsolete from all Class B institutions; and, in compliance with a request to that effect, this department caused to be shipped in the month of November the two 3.2-inch B. L. steel rifles, together with all pertaining material.

The band, under the leadership of a civilian, who has thus far had it for only six lessons, has made wonderful improvement, and well deserves all the encouragement that has been given it in the way of appropriations. A number of new instruments have been purchased, and old ones repaired. During the winter months it will play for the drills in "Butts' Manual."

All the buildings under my supervision are in good condition. The plumbing in all the buildings, as far as I can ascertain, is in good sanitary condition. I would recommend that snow guards be put on the two buildings used as dormitories; also, that additional bath rooms and water-closet facilities be added to the north dormitory.

Last year I reported that the college flagstaff had been blown down, and recommended that a new one of steel be erected, similar to the one in the town of Amherst. I again renew that recommendation. In an institution of this kind our national flag should always be displayed.

Under the provisions of General Orders, No. 101, War Department, 1905, the following-named students of the class of 1906 were reported to the Military Secretary of the Army and to the Adjutant-General of the Commonwealth, as having shown special aptitude in military exercises, viz.: Herman Augustus Suhlke, George Talbot French, Stanley Sawyer Rogers, Benjamin Strain.

Under the provisions of General Orders, No. 101, War Department, dated June 29, 1905, I quote the following: —

> The reports of the regular inspection of the colleges and schools to which officers of the army are detailed as professors of military science and tactics will hereafter be submitted annually to the general staff for its critical examinations; and the chief of staff shall report to the Secretary of War from the institutions which have maintained a high standard the six whose students have exhibited the greatest application and proficiency in military training and knowledge.
>
> The President of the United States authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded annually to an honor graduate of each of the six institutions thus designated, provided that sufficient vacancies exist after the appointment of graduates of the Military Academy at West Point and the successful competitors in the annual examination of enlisted men. By the term honor graduate is understood a graduate whose attainments in scholarship have been so marked as to receive the approbation of the president of the school or college, and whose proficiency in military training and knowledge and intelligent attention to duty have merited the approbation of the professor of military science and tactics.

This has been the rule for the past three years, but up to date no agricultural college, Class B, has received such an appointment. I believe this to be due entirely to the limited amount of time that can be given to the military department at institutions of Class B. Thus far all appointments provided for in above order have gone to institutions of Class A and Class C, schools that are essentially military schools, and where a great amount of time is devoted to the military department. I do not believe Class B institutions can compete with those of Class A and Class C in the military department.

Inasmuch as there are 45 Class B institutions and only 40 of Class A and Class C that are affected by above order, it would seem to me a better arrangement if at least two of the above appointments could go to Class B institutions, and thus create competition among them in military work. This, in my opinion, is a prize of great value, well worth striving for, and should inspire the ambition of every student. I make the above suggestion, hoping it may bear fruit by way of recommendation to the War Department, which will lead to giving Class B institutions the above-suggested two appointments.

The following is a list of ordnance and ordnance stores, property of the United States, in possession of the college: —

2 8-inch mortars, with implements (obsolete).
2 mortar beds (obsolete).
200 Krag-Jorgensen rifles, model 1898.
200 sets infantry accoutrements.
6 non-commissioned officers' swords, steel scabbards.
14 non-commissioned officers' waist belts and plates.
14 sliding frogs for waist belts.
100 paper targets, "A" and "B."
1 set of marking rods, disks and brushes for gallery practice.

All of this property is in good condition and well cared for. Two hundred and thirty-six students have received practical instruction in the military department during the year, some for only a short period, on account of not remaining in college. These figures include the class of 1906.

The organization at present is as follows: one battalion of three infantry companies, and band.

Commandant.

Capt. George Chipman Martin, Eighteenth U. S. Infantry.

Cadet Major, ... Walter Ebenezer Dickinson.

Staff.

Cadet Captain and Adjutant, .	John Nicholas Summers.
Cadet First Lieutenant and Quartermaster, ...	James Hervey Walker.
Cadet Sergeant Major, . . .	Raymond Dean Whitmarsh.
Cadet Quartermaster Sergeant, .	Carlton Craig Gowdy.
Cadet Color Sergeant, . . .	Edwin Daniels Philbrick.
Cadet Color Sergeant, . . .	Fred Alexander Watkins.

Company A.

Cadet Captain, ...	Frederick Charles Peters.
Cadet First Lieutenant, . .	Herbert Poland Wood.
Cadet Second Lieutenant, . .	Harold Edward Alley.
Cadet First Sergeant, . . .	Chester Socrates Gillett.
Cadet Quartermaster-Sergeant, .	Roland Hale Verbeck.
Cadet Sergeant, ...	Clifton Leroy Flint.
Cadet Sergeant, ...	Charles Francis Allen.
Cadet Sergeant, ...	Joseph Worcester Wellington.
Cadet Sergeant, ...	John Daniel.
Cadet Corporal, ...	Horace Wells French.

Cadet Corporal, ...	Rockwood Chester Lindblad.
Cadet Corporal, ...	Charles Sumner Putnam.
Cadet Corporal, ...	Lamert Seymour Corbett.
Cadet Corporal, ...	Thomas Webster Bean.
Cadet Corporal, ...	James Valentine Monahan.

Privates, 41; aggregate, 56.

Company B.

Cadet Captain, ...	Wayland Fairbanks Chace.
Cadet First Lieutenant, . .	Joseph Otis Chapman.
Cadet Second Lieutenant, . .	Clinton King.
Cadet First Sergeant, . . .	Thomas Addis Barry.
Cadet Quartermaster-Sergeant, .	John Robert Parker.
Cadet Sergeant, ...	John Albert Anderson.
Cadet Sergeant, ...	Parke Warren Farrar.
Cadet Sergeant, ...	Lai-Kwei Liang.
Cadet Sergeant, ...	William Franklin Turner.
Cadet Corporal, ...	Myron Wood Thompson.
Cadet Corporal, ...	Leroy Henry Turner.
Cadet Corporal, ...	Samuel Sutton Crossman.
Cadet Corporal, ...	Elmer Francis Hathaway.
Cadet Corporal, ...	John F. O'Donnell.
Cadet Corporal, ...	Charles Russell Webb.

Privates, 41; aggregate, 56.

Company C.

Cadet Captain, ...	Clifford Briggs Thompson.
Cadet First Lieutenant, . .	Ralph Jerome Watts.
Cadet Second Lieutenant, . .	John Thomas Caruthers.
Cadet First Sergeant, . . .	Harry Milliken Jennison.
Cadet Quartermaster-Sergeant, .	Hermon Temple Wheeler.
Cadet Sergeant, ...	Carleton Bates.
Cadet Sergeant, ...	Arthur James Farley.
Cadet Sergeant, ...	Samuel Judd Wright.
Cadet Sergeant, ...	William John Coleman.
Cadet Corporal, ...	Roger Sherman Eddy.
Cadet Corporal, ...	Harry Orrison Knight.
Cadet Corporal, ...	Richard Potter.
Cadet Corporal, ...	Harold Gordon Neale.
Cadet Corporal, ...	Paul Edgar Alger.
Cadet Corporal, ...	Leon Clark Cox.

Privates, 41; aggregate, 56.

Band.

Cadet Captain, ...	George Henry Chapman.
Cadet First Lieutenant, . .	Earle Goodman Bartlett.
Cadet Drum Major, . . .	Frederick Augustus Cutter.

Cadet Sergeant, ...	Edward Houghton Shaw.
Cadet Sergeant, ...	Milford Henry Clark, Jr.
Cadet Sergeant, ...	Jaspar Fay Eastman.
Cadet Corporal (leader), . .	Kennith French Gillett.
Cadet Corporal, ...	Lloyd Warren Chapman.
Cadet Corporal, ...	Roy Edward Cutting.
Cadet Corporal, ...	Allan Dana Farrar.
Cadet Corporal, ...	James Augustus Hyslop.
Cadet Corporal, ...	Raymond Hobart Jackson.

Privates, 10; aggregate, 22.

Total in military department: 1 major, 5 captains, 5 first lieutenants, 3 second lieutenants, 1 sergeant major, 1 battalion quartermaster-sergeant, 2 color sergeants, 3 first sergeants, 1 drum major, 3 company quartermaster-sergeants, 15 sergeants, 24 corporals, 133 privates, aggregate 197.

Respectfully submitted,

GEORGE CHIPMAN MARTIN,
Captain, Eighteenth United States Infantry, Commandant.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Value of Additions to Equipment during the Year ended June 30, 1906.

1. Library,	$1,000 00
2. Apparatus,	200 00
3. Buildings,	37,000 00
4. Live stock,	2,001 00
Total,	$40,201 00

II. Receipts for and during the Year ended June 30, 1906.

1. State aid: —	
(*a*) Income from endowment,	$3,313 32
(*b*) Appropriations for current expenses,	40,250 00
(*c*) Appropriations for buildings or for other special purposes,	51,650 00
2. Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) Additional endowment, act of Aug. 30, 1890,	16,666 66
3. Fees and all other sources,	7,648 36
Total,	$126,828 34
4. Federal appropriation for experiment stations, act of March 2, 1887,	$15,000 00

III. Property, Year ended June 30, 1906.

Value of buildings,	$252,775 00
Value of other equipment,	$169,372 61
Total number of acres,	404
Acres under cultivation,	275

Acres used for experiments,	60
Value of farm and grounds,	$44,350 00
Number of acres of land alotted to State under act of July 2, 1862,	360,000
Amount of land grant fund of July 2, 1862,	$219,000 00
Amount of other permanent funds,	$142,000 00
Number of bound volumes in library June 30, 1906,	26,944

IV. Faculty during the Year ended June 30, 1906.

College of Agriculture and Mechanic Arts, collegiate and special classes,	32
Number of staff of experiment station,	26

V. Students during the Year ended June 30, 1906.

College of Agriculture and Mechanic Arts, collegiate and special classes,	262
Graduate courses,	8
Total, counting none twice,	270

THE NEW BOTANICAL LABORATORY.

Clark Hall, the new botanical laboratory now nearly completed at this college, for which the last Legislature appropriated $45,000, will be one of the most substantial and artistic buildings on the college grounds. The plans for the structure are from the office of Cooper & Bailey, the well-known Boston architects. It is of a mixed style of architecture, coming nearest to the colonial, adapted from the English. The dimensions are 95 by 55 feet, with an eight-foot projection on the east side. The base is of granite and the rest of red brick, the whole having ornamentation of pressed brick and marble. The roof and gutters are of copper, canvas and slate.

Clark Hall is to be devoted to teaching and experimental purposes, and the work previously carried on in the department of vegetable physiology and pathology, at the East experiment station, and in the botanical museum, will now be conducted in Clark Hall. The new building contains a large recitation room capable of seating about 140 students, built in the amphitheatre style. This room is intended to be supplied with automatic working curtains, for use with the stereopticon. There is also a museum room on the first floor, which will be used for a lecture room, with a capacity of about 65 or 70 students. The museum proper consists mainly of cases on the wall, leaving the interior of the room free for class room work. The east side of the building is devoted to experiment station purposes, and includes rooms for special laboratories, and office, library and herbarium.

On the second floor there is a large laboratory for freshmen and junior work, capable of accommodating about 75 men. There is also a laboratory for seniors, with ample accommodations, together with rooms for graduate and special students. The Knowlton herbarium will be preserved in a room in the upper story, which will be used as a small lecture and seminar room.

On the third floor, or attic, there are two sleeping rooms and

a study room for the caretakers of the building, which will be provided with bath and toilet rooms. From the attic there are stairs leading to a platform on the roof which commands an excellent view of the college grounds.

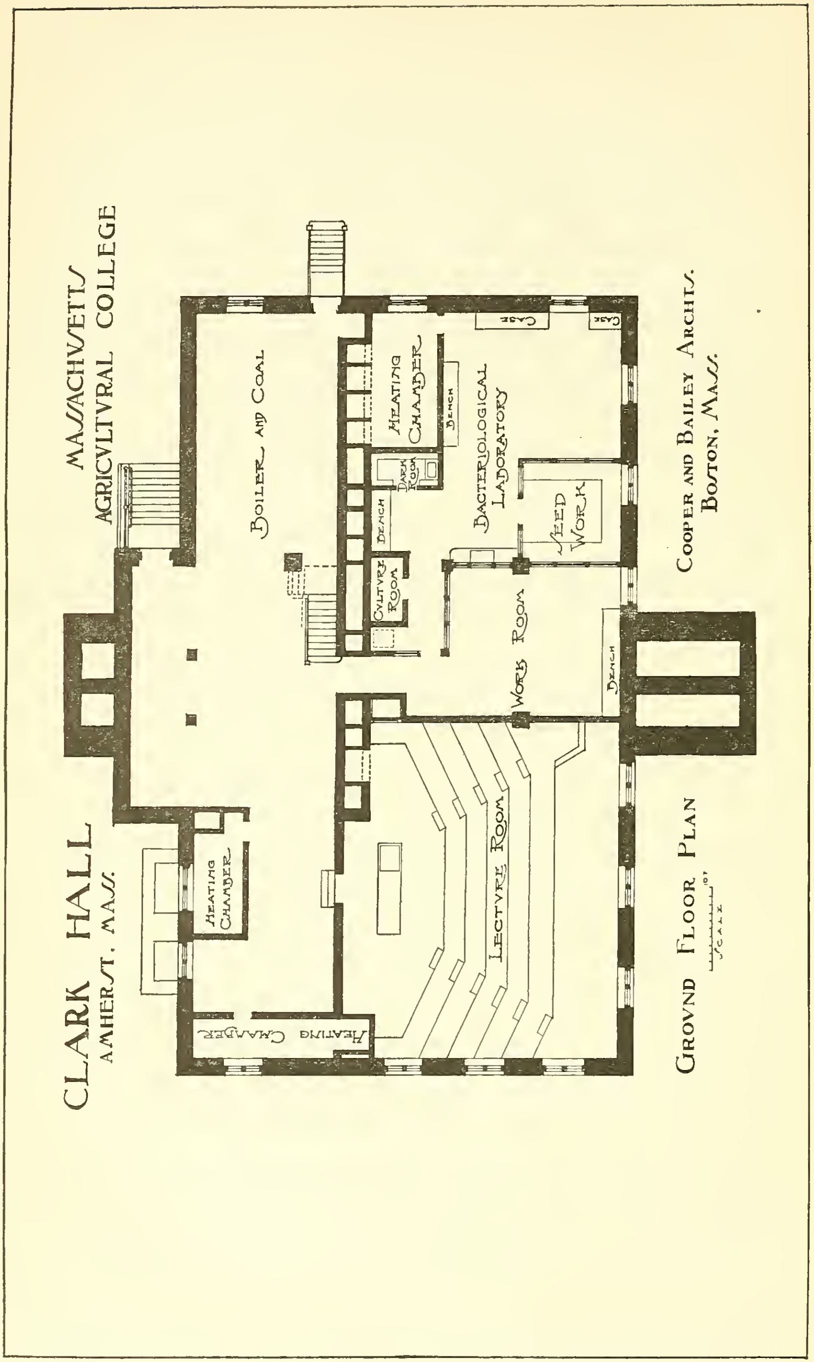
A portion of the basement is well lighted, and will be used for various lines of work connected with seed testing, separation, soil work, etc. Provision is also made for a tool room and a large bacteriological laboratory, which will be equipped for the study of problems connected with the bacteriology of soils, etc.

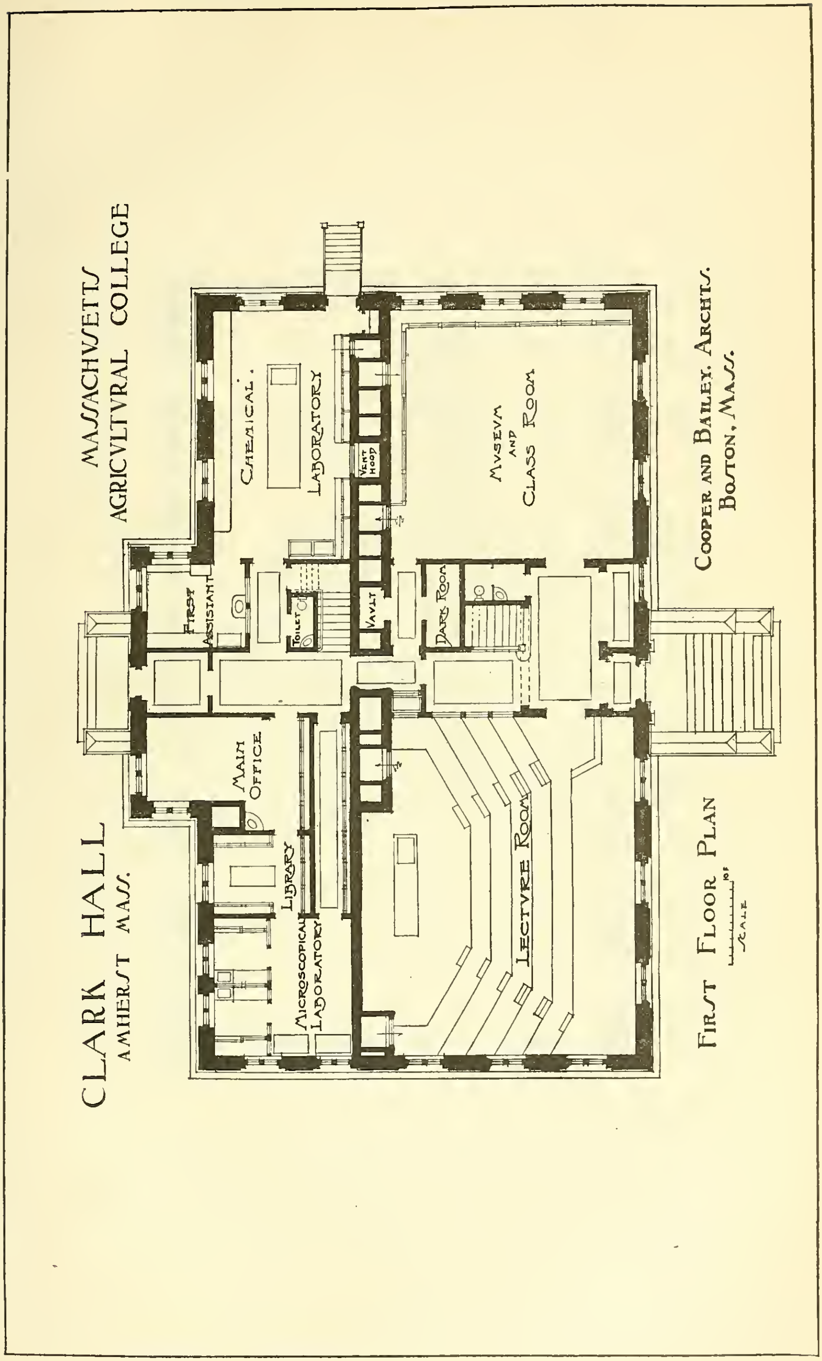
A small greenhouse for special experimental work, in the place of that previously used at the east experiment station, will be constructed on the south side of the building. This will be devoted to the study of the diseases of the most important greenhouse crops.

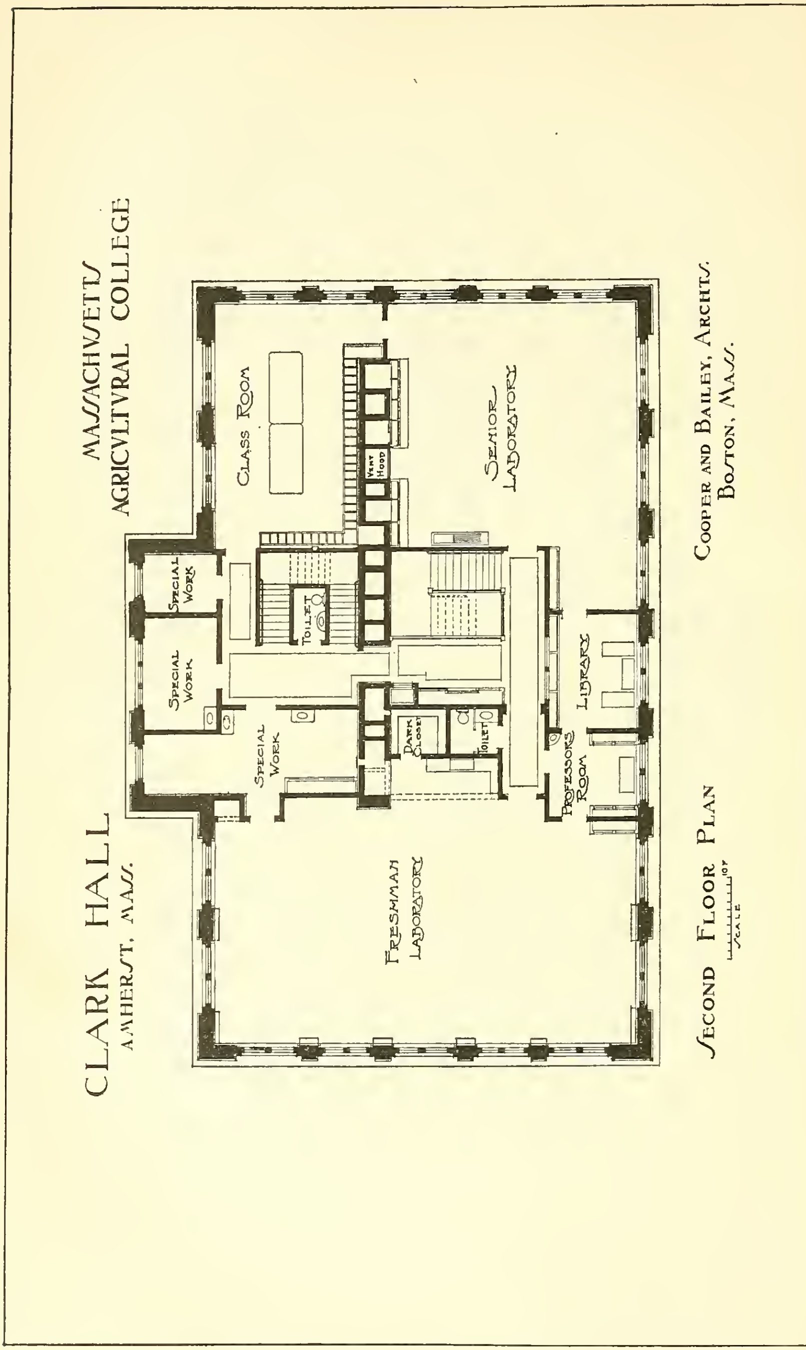
The construction of Clark Hall will not be quite fireproof, but would be classified for insurance purposes as "slow-burning." It is unexposed by any fire hazard, and will be equipped with hose connected with standpipes and chemical extinguishers; therefore there is only the remotest possibility of the building ever being seriously damaged by fire.

The object of the trustees and architects has been to combine, in a marked degree, beauty and utility in this structure, and to provide a convenient, permanent home for this department of the college.

It is very fitting that the building should be named after Col. W. S. Clark, one of the first presidents of the college, whose ability, enthusiasm and great versatility are recognized at the present time as well as in former years.


CLARK HALL
AMHERST, MASS.
MASSACHVSETTS
AGRICVLTVRAL COLLEGE
BOILER AND COAL
HEATING CHAMBER
DARK ROOM
BENCH
BACTERIOLOGICAL LABORATORY
CASE
CASE
SEED WORK
CVLTVRE ROOM
WORK ROOM
BENCH
WORK ROOM
LECTVRE ROOM
HEATING CHAMBER
HEATING CHAMBER
GROVND FLOOR PLAN
SCALE
COOPER AND BAILEY ARCHTS.
BOSTON, MASS.


CLARK HALL
AMHERST MASS.
MASSACHUSETTS
AGRICULTURAL COLLEGE
CHEMICAL LABORATORY
VENT HOOD
VAULT
TOILET
FIRST ASSISTANT
MAIN OFFICE
LIBRARY
MICROSCOPICAL LABORATORY
LECTURE ROOM
DARK ROOM
MUSEUM AND CLASS ROOM
COOPER AND BAILEY, ARCHTS.
BOSTON, MASS.
FIRST FLOOR PLAN
SCALE


MASSACHUSETTS
AGRICULTURAL COLLEGE
CLARK HALL
AMHERST, MASS.
CLASS ROOM
SENIOR LABORATORY
VENT HOOD
SPECIAL WORK
SPECIAL WORK
SPECIAL WORK
TOILET
TOILET
DARK CLOSET
LIBRARY
PROFESSORS ROOM
FRESHMAN LABORATORY
COOPER AND BAILEY, ARCHTS.
BOSTON, MASS.
SECOND FLOOR PLAN
SCALE

NINETEENTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

JANUARY, 1907.

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
JAMES DRAPER.
SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Honorary Director and Chemist* (fertilizers).
WILLIAM P. BROOKS, Ph.D.,	*Director and Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
JOSEPH B. LINDSEY, Ph.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
JAMES B. PAIGE, D.V.S.,	*Veterinarian.*
ERWIN S. FULTON, B.Sc.,	*Assistant Agriculturist.*
NEIL F. MONAHAN, B.Sc.,	*Assistant Botanist.*
HENRI D. HASKINS, B.Sc.,	*First Assistant Chemist* (fertilizers).
EDWARD G. PROULX, B.Sc.,	*Second Assistant Chemist* (fertilizers).
E. THORNDIKE LADD, B.Sc.,	*Third Assistant Chemist* (fertilizers).
EDWARD B. HOLLAND, M.S.,	*First Chemist* (foods and feeding).
PHILIP H. SMITH, B.Sc.,	*Assistant Chemist* (foods and feeding).
LEWELL S. WALKER, B.Sc.,	*Assistant Chemist* (foods and feeding).
WILLIAM K. HEPBURN,	*Inspector* (foods and feeding).
HOWARD A. PARSONS,	*Dairy Tester* (foods and feeding).
ROY F. GASKILL,	*Assistant in Foods and Feeding.*
CHARLES P. HALLIGAN, B.Sc.,	*Assistant Horticulturist.*
EDWIN F. GASKILL, B.Sc.,	*Assistant Agriculturist.*
T. A. BARRY,	*Observer.*

REPORT OF THE DIRECTOR.

During the past year the work of the station has for the most part followed the usual lines, but an important change in policy, as affecting college and station, should be noted. Early last year it was voted by the Board of Trustees to separate the administrative duties of the presidency of the college and the directorship of the station, and a director was elected. The station, it will be remembered, is a department of the college, and the director, therefore, is responsible to the president. He is made *ex officio* a member of the committee of the Board of Trustees on the experiment department, without vote. Although this change, as stated, was voted early last year, it did not become practically operative until early in July, for up to that time the director-elect served as acting president of the college as well as director, so that his time and energies were divided.

The Adams Act.

The past year has been rendered notable in station history by the passage of the Adams act, granting additional appropriations to all the agricultural experiment stations of the country. This act takes its name from the late Hon. H. C. Adams of Wisconsin, who labored long and earnestly to secure its passage, and who perhaps in a very real sense gave his life for the passage of the bill which bears his name.

The Adams bill provided an appropriation by the national government of $5,000 to each experiment station for the year ended June 30, 1906. It provides for an increase of $2,000 in the amount appropriated for each station annually until the total amount per year for each State reaches $15,000, at which figure it is then to remain. This act will then, in brief,

within a few years double the amount of the national appropriations to each of the experiment stations of the country. This act was approved on March 16, 1906. There was for a time doubt as to whether the first installment of $5,000 would become available during the fiscal year ended June 30 last. A final decision was not made until very late in June. The passage of the act had, however, been anticipated, and, in preparation for an increase in the scope of station work, the principal part of the first installment was used in the purchase of scientific apparatus. The Adams bill stipulates that the funds which it makes available are "to be applied only to all the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States." It should by the terms of the bill be devoted to research of the highest scientific character. No part of the funds made available by the Adams bill can be used for ordinary administrative expenses or for publication.

The bill was so drawn that acceptance of its provisions by the Legislatures of the several States was a necessary prerequisite to the reception of the funds which it provided. Such acceptance on the part of the Legislature of Massachusetts was promptly obtained.

Change in the Name of the Station.

At the time when work was organized under the Hatch act, establishing experiment stations as departments of agricultural colleges, there was already in existence in Amherst a station organized under State law, known as the Massachusetts Experiment Station. It will be remembered that for some years the two stations continued in operation side by side and without disadvantage, for there was agreement as to the lines of investigation to be undertaken by each, and there was no duplication of work. The fact that the name Massachusetts Experiment Station was already in use made it necessary to adopt another name; and, as a mark of respect to Senator Hatch, to whose activity and influence the establishment of the stations under the general government had been due, this experiment department in Massachusetts was called the Hatch Experiment Station. In the course of a few

years it became apparent that superior economy in the administrative work of the Massachusetts stations might be secured should both come under one organization. An act of the Legislature was secured, uniting the State station with the Hatch station, and under the latter name. The use of this name has been attended with numerous minor disadvantages. The reason for its adoption is not generally understood. It is contrary to the custom in other States to give the stations a special name; in all other States the station is known by the name of the State. It has therefore seemed best to conform to this general practice, and the name of this station by act of the Legislature recently secured has been changed to the Massachusetts Agricultural Experiment Station.

Changes in Staff.

No very important changes in the general policy of the station have been made during the year, and yet it has been a year of progress. The station has been fortunate in retaining the services of all the heads of its various divisions, and in June last the scope of its work was extended through the establishment of a division of veterinary science, of which Dr. James B. Paige was made the head.

A considerable number of minor changes in the station staff have been made necessary, owing to the fact that assistants in various departments have left us to take positions of greater responsibility and emolument. These changes have been as follows: —

E. S. Fulton, B.S., in place of F. R. Church, B.S.

E. F. Gaskill, B.S., appointed assistant agriculturist, in place of S. B. Haskell, B.S.

Howard S. Parsons, dairy tester, in place of Sumner R. Parker, B.S.

Charles P. Halligan, B.S., assistant horticulturist, in place of Walter B. Hatch, B.S.

Lewell S. Walker, B.S., assistant chemist, in place of Arthur C. Whittier, B.S.

W. K. Hepburn, inspector, in place of Frank G. Helyar, B.S.

T. A. Barry, observer, in place of C. H. Chadwick.

The correspondence, as pointed out by the heads of a number of divisions, has largely increased. This increase has affected not simply the heads of divisions, but the director's office as well, and has made necessary the employment of an increased number of private secretaries. The clerical work of the station now affords full employment for from five to six such assistants.

New Lines of Work.

During the past year two new lines of work have been undertaken, in both instances at the solicitation and with the hearty co-operation of persons engaged in the special industries affected.

Asparagus growing is an important industry in a number of sections. Of late years it has been found difficult to produce satisfactory crops, on account of the prevalence of rust. It is hoped that it may be possible to obtain or to produce more rust-resistant varieties of this crop; and, for the purpose of working with that end in view, an arrangement has been made with the division of plant industry of the department of agriculture for co-operative work. Much of this work will be carried on in Concord, which is the center of what is without doubt the most important asparagus-producing section in the State. In connection with the asparagus-breeding experiments in Concord, an extended series of fertilizer experiments is also to be undertaken. Considerable preliminary work in both directions has been done during the past year.

The cranberry industry, which is so important chiefly in the seaboard towns of southeastern Massachusetts, has long suffered from a variety of insect pests. An important beginning has been made in the study of these pests during the past season. In this work the station has employed an assistant, who spent the entire summer in Wareham, which is one of the principal towns of the cranberry district of Plymouth County. The results of his work and important suggestions as to methods of fighting the injury due to some of the more serious insect pests will be presented in a bulletin, which will be ready for publication at an early date.

An extended series of experiments in the use of fertilizers for cranberries has also been begun during the past year. The bogs where these experiments are in progress under direct station management are located in Falmouth. An almost equally extensive series of experiments with fertilizers has been begun on the bogs of one of the largest private growers.

Revision of Mailing Lists.

The mailing lists of the station have been kept by the card catalogue system, and have not been revised for a number of years. These lists include a total of some 25,000 cards. It is believed that they may include duplicates, and a considerable number of names of parties who no longer care for our publications, — possibly of persons deceased or removed. An important beginning has been made in the revising of these lists. The revision now in progress will be made of the most thorough possible character, and as soon as it can be completed, improved systems of addressing and mailing will be installed.

Work under the Adams Act.

Careful plans have been laid for investigations under the Adams act. These investigations, as will be evident from the statement made concerning the nature of the work which can be undertaken under it, will usually extend over a considerable number of years. A portion of the work with asparagus and cranberries, which has been referred to, will be provided for out of the funds furnished by this act.

Among other lines of work which have been begun are investigations to determine the effect of feed on the composition of milk and butter fat and on the consistency or body of butter; the effect of Porto Rico molasses on the digestibility of hay, and of hay and a nitrogenous concentrate; the preparation of descriptions and life histories of important groups of insects; and a study of the relations of climate to the development of plants and crops both in health and disease.

Bulletins issued.

Meteorological bulletins have been issued monthly, as usual, and in addition the station has published and distributed four other bulletins, — two on fertilizers, one on the inspection of concentrates and one on market milk.

The fertilizer bulletins, Nos. 109 and 111, have presented the analyses of the fertilizers officially examined under the fertilizer law, as well as the analyses of a considerable number of soils and the more abundant miscellaneous materials possessing fertilizer value, which are sent in by the general public. They have also included brief discussions of the results.

The bulletin on the inspection of concentrates, No. 108, besides presenting the results of the analyses of food stuffs collected under the feed law, included much valuable information on the general subject of food stuffs and their use.

The bulletin on market milk, No. 110, included: first, general discussion of the composition and value of milk as food; second, it presented the results of an examination into the conditions under which the milk marketed in parts of Northampton and Amherst is produced, as well as the results of a critical examination of samples of this milk. The milk was subjected to physical, chemical and bacteriological tests, for the purpose of determining its quality, value and suitability as human food. The results are carefully and fully discussed, and some of the more important conclusions presented were as follows: Very little milk showed evidence of adulteration, and most of it was sweet. The larger part of it was above the average in chemical composition. Bacteria were especially numerous in the product of cows kept under uncleanly conditions, and such samples were far too numerous. Many samples showed barny or disagreeable smell, apparently due to the fact that the milk was allowed to stand too long in the stable after milking. The general conclusion was, that a great deal of the milk offered for general consumption was not produced under satisfactory sanitary conditions. The bulletin concludes with brief, important and pointed practical suggestions both to producers and to consumers.

Besides the bulletins which have been mentioned, three others have been prepared, and are now in press: No. 112, "The Examination of Cattle and Poultry Feeds;" No. 113, "Fertilizer Bulletin;" and No. 114, "The Oriental Moth: a Recent Importation."

Bulletins and Reports available for Free Distribution.

The supply of many of the reports and bulletins which have been issued by the station, available for general distribution, has been exhausted, but those in the following list will still be furnished on application: —

No. 3. Tuberculosis.
No. 33. Glossary of fodder terms.
No. 34. Fertilizer analyses.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 64. Analyses of concentrated feed stuffs.
No. 68. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 92. Fertilizer analyses.
No. 96. Fungicides; insecticides; spraying calendar.
No. 97. A farm wood lot.
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.
No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.
No. 105. Tomatoes under glass; methods of pruning tomatoes.

No. 107. Analyses of manurial substances forwarded for examination; market values of fertilizing ingredients; analyses of licensed fertilizers collected in the general markets.

No. 109. Analyses of manurial substances forwarded for examination; analyses of Paris green and other insecticides found in the general markets; instructions regarding the sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients for 1906.

No. 110. Market milk.

No. 112. The examination of cattle and poultry feeds.

No. 113. Fertilizer analyses.

No. 114. The oriental moth: a recent importation.

Of most of the other bulletins of the station a few copies still remain; these will be supplied only to complete sets for libraries.

The co-operation and assistance of farmers, fruit growers and horticulturists, and all interested directly or indirectly in agriculture, is earnestly requested. Communications may be addressed to the "Massachusetts Agricultural Experiment Station, Amherst, Mass."

Reports of Divisions.

The reports of the different heads of divisions are transmitted herewith.

The report of the meteorologist calls attention to two or three important improvements in equipment.

The report of the agriculturist is elsewhere briefly summarized.

The report of the fertilizer section of the division of chemistry calls attention to a moderate increase in the number of fertilizers licensed in the State and in the number analyzed. Three hundred and fifty-four brands of fertilizers and chemicals have been licensed in Massachusetts during the year. As was pointed out in the last annual report, there can be no possible necessity for such a large number of different kinds of fertilizers. The report of the chemist this year emphasizes this point. It should be more generally understood that

the fertilizers purchased by the farmer cost more as a consequence of this needless multiplication of brands. It would seem to be the part of common sense for the manufacturers to reduce their number, for whatever enables them to lower the price to the consumer must eventually help manufacturer and dealer as well as consumer. The fertilizers analyzed during the past year have shown an improvement in quality, as compared with stated composition. No particular improvement can be noted in the direction of better adaptation to crops. The different brands of special crop fertilizers show the same extreme variations as heretofore. It is evident that not all of the fertilizers advertised as suitable for any particular crop can possibly meet the promises of the manufacturers. The analyses completed by the station show some decline in the general quality of wood ashes, and the report emphasizes the desirability that consumers of ashes should purchase only on a guarantee as to quality.

The report of the section of foods and feeding is largely devoted to the presentation of the results of experiments to determine the digestibility of some of the newer food stuffs. The publication of such results seems to be essential as a basis for proper use of such materials. The report calls attention to the general results of the analyses of samples of drinking water, which indicate, as in previous years, the necessity of caution in cases where contamination seems possible or is suspected. The report includes also brief statements of the results of the execution of the feed and dairy laws. Dealers in food stuffs seem in general disposed to comply with the law, although in a few cases it is believed that retailers are in the habit of removing or failing to attach labels required by the law. Attention is called to the fact that the tests of Babcock glassware for accuracy show a comparatively large proportion to be inaccurately graduated. There is much need of greater care on the part of manufacturers.

The results of a feeding trial in which Porto Rico molasses was tested are presented. They show such molasses to have apparently about 80 per cent. of the value of corn meal. Attention, however, is called to the fact that molasses depresses the digestibility of other foods. Should it be found that such

depression inevitably follows the use of molasses, this consideration will materially decrease its value as a food stuff.

Feeding experiments with alfalfa meal indicate that it is not equal to wheat bran in food value, as is claimed by some of its manufacturers.

Experiments with sorghum as a fodder show that the large quantities of seed sometimes recommended are unnecessary, and that the fodder fills a useful place in a soiling system.

The report of the botanist and vegetable pathologist covers a considerable variety of topics. Attention is called to the tonic influence of Bordeaux mixture on plant assimilation. As a result of this influence, it seems apparent that the benefit following the application of Bordeaux mixture is not due solely to the prevention of disease, but in considerable measure as well to increased vigor of growth.

Attention is called to the importance of further study for the discovery of a remedy for tomato rot, which so seriously injures the greenhouse crop in this State.

The report shows a considerable increase in the amount of work done by the station in testing seeds for farmers and gardeners. It presents a review of the year as regards the prevalence of plant diseases. It seems that during the past year the potato has been comparatively free from disease, while celery, pears and apples have been affected to an unusual degree. The report calls attention to defoliation of fruit trees not infrequently following improper spraying, and makes important suggestions in connection therewith.

Attention is called to a bacterial disease of cucumbers under glass. It has been found that relatively late planting insures absolute or comparative freedom from this disease. A bacterial disease of lettuce is common in the south, and growers are cautioned to be on the outlook for similar disease in their houses. The promptest measures should be taken to eradicate it, should it appear.

Attention is called to a serious trouble which tobacco growers have experienced within the last year or two, which appears to be due to improper use of fertilizers.

It is pointed out that the lime and sulfur treatment now so often adopted as a means of destroying the San José scale

exercises a repressive influence upon a number of fungous diseases. It has been noted that fruit trees have been remarkably free from such diseases, and the fruit unusually perfect and free from imperfections where the lime and sulfur treatment has been practiced, and the opinion is expressed that the San José scale may prove " a blessing in disguise."

A brief report is presented of the trial of a number of different fungicides for potatoes. The wet Bordeaux mixture was found to be superior to any of the dry applications, but the results of the season are comparatively inconclusive.

The report includes an important paper upon banding substances which are used for the protection of trees and shrubs from insects. Relatively few of the substances upon the market satisfy all the requirements in such a material. A number of them prove highly injurious if applied direct to the bark.

The report of the botanist includes a paper on the injury to trees caused by illuminating gas. It appears that a large amount of careless work has been done in the putting in of gas mains. The injury to trees consequent upon the escape of illuminating gas into the soil surrounding their roots has in a number of instances proved very serious.

The report concludes with a discussion as to the varying texture of soil required for some of our more important special crops.

The report of the entomologists calls attention to the large amount of injury to various greenhouse crops consequent upon the attacks of the white fly. Fumigation with hydrocyanic acid gas has been found the most successful method of destroying this insect, but the results of such fumigation have in numerous instances resulted in great injury to the plants fumigated. The capacity of different plants to endure such fumigation is for the most part unknown. This subject has been carefully investigated for greenhouse tomatoes, and a bulletin soon to be published will present the results and give definite directions. The report calls attention to the rapid spread of the San José scale, which seems to be at present distributed in nearly every town east of the Connecticut River. The scale is found in old as well as in recently set trees. The re-

port calls attention to the fact that earlier experiments here showed the lime and sulfur treatment to be the most effective. Later investigation confirms these early results. The report deals briefly with a number of the proprietary mixtures recommended for the destruction of the San José scale, but states that none of them has been found equal to the lime and sulfur mixture. The report makes mention of the work on cranberry insects and the investigation as to the newly imported oriental moth, both of which have been previously referred to. It concludes with brief reference to some of the more destructive insects of the year.

The report of the veterinarian briefly discusses the nature of the work which his department has been called upon to do. It will be remembered that this division has been organized only since July.

The report of the horticulturist makes brief mention of the different lines of experimental work in progress, and reports in detail the results of experiments in mushroom growing. These indicate pure-culture spawn to be much superior to the ordinary commercial spawn, and that there is a wide difference in the characteristics of different varieties as regards productiveness and quality. The results indicate that the possibilities of profit in mushroom culture are by no means as great as is often represented.

WILLIAM P. BROOKS,
Director.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1906.

Cash received from United States Treasurer,		$14,617 70
Unexpended balance, 1904–05,		382 30
		$15,000 00
Cash paid for salaries,	$6,539 52	
for labor,	3,003 07	
for publications,	719 01	
for postage and stationery,	438 09	
for freight and express,	168 01	
for heat, light, water and power,	245 42	
for chemical supplies,	406 54	
for seeds, plants and sundry supplies,	525 57	
for fertilizers,	569 43	
for feeding stuffs,	699 10	
for library,	21 10	
for tools, implements and machinery,	246 05	
for furniture and fixtures,	51 52	
for scientific apparatus,	292 62	
for live stock,	195 25	
for travelling expenses,	229 66	
for contingent expenses,	25 00	
for building and repairs,	625 04	
		$15,000 00

Cash received from State Treasurer,	$13,500 00	
from fertilizer fees,	4,745 00	
from farm products,	2,836 02	
from miscellaneous sources,	4,993 76	
		$26,074 78

Cash paid for salaries,	$13,411 67	
for labor,	2,220 35	
for publications,	809 52	
for postage and stationery,	394 61	
for freight and express,	186 63	
for heat, light, water and power,	1,118 36	
for chemical supplies,	237 79	
for seeds, plants and sundry supplies,	680 65	
for fertilizers,	67 55	
for feeding stuffs,	902 65	
for library,	142 60	
for tools, implements and machinery,	58 10	
for furniture and fixtures,	212 13	
for scientific apparatus,	1,210 72	
for live stock,	10 00	
for travelling expenses,	1,587 59	
for contingent expenses,	88 10	
for buildings and repairs,	170 47	
Balance,	2,495 29	
		$26,074 78

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division during the past year has been continued along the same lines as in previous years. While changes in the instruments at times are necessary, and a modification in the form of the records must occasionally be made, these are avoided unless the necessity is very apparent. The value of a set of records at any station is dependent on the uniformity with which they have been made, as well as on the length of time covered. Notwithstanding the objections to a change, it was considered advisable at the beginning of the year to discontinue the publication of the wind movement as given by the Draper anemometer, and to use instead that given by the electric register which was installed last year. This was done so that our records would be better comparable with those of the United States Weather Bureau meteorological stations, which use electric recorders. A comparison of the two records at this station shows a difference of from 5 to 10 per cent. in the total movement during a month, that of the electric register usually being the larger. The Draper records are still taken, and will be continued during the coming year for the purpose of further comparison.

The records of the electric sunshine recorder have been substituted for those of the Draper instrument, and, while they are made more precise, it is not thought that the monthly results are materially affected by the change.

With the close of the year the records for eighteen years will be complete. A summary of the records for the first ten years was published in the report for 1900. This summary has been carried along to date for the purpose of deducing

mean values which are taken for the normals of the station. It should again be published when the records for twenty years are completed.

The usual monthly bulletins have been issued, and the one for December will contain a summary of the records for the year. The station has also furnished the Boston office of the United States Weather Bureau with the monthly voluntary observers' reports, and has arranged to send weekly snow reports during the winter season.

The local forecasts are received by telegraph daily, Sundays excepted, from the Boston office, and the proper flags are displayed.

During the year a new Draper self-recording thermometer was purchased, to replace the one in use. A new maximum thermometer of standard pattern was purchased, to replace the one in use which was broken in resetting. A Felt and Tarrent comptometer has been added to the equipment, and is used in making many of the computations. All computations are checked, to reduce the probability of errors to a minimum.

In February Mr. C. H. Chadwick, the observer, retired to accept a position in civil engineering in the south; and the assistant observer, Mr. T. A. Barry, was advanced to the place.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANTS, E. S. FULTON, E. F. GASKILL.

The work carried on in the agricultural division of the experiment station during the past season has involved the care of 308 field plots in the various fertilizer and variety tests; 150 closed plots, largely used in fertilizer experiments; and 286 pots in vegetation experiments, mainly designed to throw light upon problems connected with the use of fertilizers. It will be remembered that a large number of the experiments in this division are continued from year to year. Such repetitions are desirable, for reasons which are fully set forth in the last annual report. A detailed account of results obtained will at this time be presented only for a relatively small number of the experiments in progress. The experiments discussed, and the more important results, briefly stated, are as follows: —

I. — Experiment to determine the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. This experiment has been in progress since 1890. The crop of this year was corn, and on the basis of yield the nitrogen materials under comparison rank in the following order: barnyard manure, nitrate of soda, sulfate of ammonia, dried blood. On the basis of increase in crop, as compared with the product of the no-nitrogen plots, taking into account all the crops grown since the experiment began (1890), the materials on a percentage basis rank as follows: nitrate of soda, 100; barnyard manure, 85.31; dried blood, 70.06; sulfate of ammonia, 63.54.

II. — Experiment to determine the relative value of muriate and high-grade sulfate of potash. The crops on the basis of which comparisons are possible this year were soy beans,

asparagus, rhubarb, raspberries, blackberries, mixed hay and potatoes. The sulfate of potash gives the larger crops in the case of soy beans, rhubarb, raspberries, blackberries, potatoes, and (as the average of two experiments) for mixed hay. The muriate gives the larger crop of asparagus.

III. — Experiment to determine the relative value of different potash salts for field crops. The salts under comparison were kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The crop was potatoes. The salts on the average of five trials for each rank as follows: muriate, low-grade sulfate, high-grade sulfate, nitrate, carbonate, kainit and silicate. Where potash is not used as a fertilizer, the vines appear to be far more susceptible to early blight than on the other plots.

IV. — Experiment to show the relative value in corn and hay production of special corn fertilizers, as compared with a fertilizer mixture richer in potash. The crop of the past season was mixed grass and clover. The special corn fertilizer gave the larger yield at the first cutting, the fertilizer richer in potash the larger yield of rowen. This experiment has continued since 1891. Ten corn crops and six crops each of hay and rowen have been produced. As the average of the entire number of experiments, the special corn fertilizer has given a slightly larger yield of grain and less stover than the mixture of materials richer in potash. As the average of six years' results, the mixture richer in potash has given the larger crops both of hay and rowen.

V. — Experiment to determine the relative value for production of corn and mixed hay of manure alone, as compared with a smaller application of manure and a moderate amount of sulfate of potash. The crop of the past year was mixed hay. The larger application of manure alone gave slightly larger yields both at the first and second cuttings than the combination of the smaller amount of manure and potash. This experiment has continued sixteen years. Ten corn crops and six crops each of hay and rowen have been harvested. The average yields both of corn and hay have been greater on the larger amount of manure alone, but not sufficiently greater, estimating the manure to cost $5 per cord, to cover

the larger cost of the manure applied to those plots where it is used alone.

VI. — Experiment to determine the relative value, as measured by crop production, of a considerable number of phosphates used in quantities to furnish equal phosphoric acid to each plot. The phosphates under comparison are fine ground, — apatite, South Carolina rock and Tennessee rock phosphates; Florida soft phosphate, basic slag meal, dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. The crop of the past season was mixed hay. The yields on the different phosphates varied relatively little, indicating that the hay crop is dependent in far less degree upon the quantity of available phosphoric acid applied than are the crops belonging to the Cruciferæ, such as cabbages and turnips, as shown by previous trials.

VII. — Soil tests. The past season was the eighteenth during which the soil test reported in detail has continued. The results show the great importance of a supply of nitrogen in highly available form for the production of a satisfactory hay crop.

VIII. — Experiment in applying manurial substances in rotation for the production of grass. The materials applied in the rotation are: first, barnyard manure; second, wood ashes; and third, a combination of fine-ground bone and potash. The average yield of hay during the past season was at the rate of 4,002 pounds per acre. The average for the fourteen years during which the experiment has continued has been 6,389 pounds.

IX. — An experiment comparing winter with spring application of manure on a slope. The crop of the past year was corn, and the results indicate a small loss in fertilizer value, resulting from winter application, but the gain in crop where the manure was applied in spring was not sufficient to repay the extra cost in handling the manure in that manner.

X. — Experiment in the application of nitrate of soda for rowen. The increase in crop during the past season was considerably more than sufficient to cover the cost of the application; but the results in the different years that the experiment has continued show a wide variation with the amount of rainfall during the season of growth of the crop.

XI. — A variety test of potatoes, including twenty-five varieties. The most productive varieties, mentioned in order, were: Climax, Chenango White, Hammond's Wonderful and Simmon's Model, all of which gave a yield in excess of 200 bushels merchantable potatoes per acre.

XII. — Comparisons of food combinations furnishing the essential nutrients in varying proportions for laying hens. The results indicate corn to have superior merit among the different grains for the production of eggs whenever the total fiber content of the ration is low, and the fat content relatively high. Rice, which contains less fiber than any other grain, gives a satisfactory egg product, but costs too much to render its use advisable.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The materials furnishing nitrogen which are under comparison in this experiment are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. The field includes eleven plots, of one-tenth acre each. All the plots annually receive equal and liberal amounts of phosphoric acid and potash. The phosphoric acid is supplied to all plots in the form of dissolved bone black. The potash is applied to six plots (1, 3, 6, 7, 8 and 9) in the form of muriate; it is applied to four plots (2, 4, 5, and 10) in the form of low-grade sulfate. There are three plots in the field which have had no nitrogen applied to them in any form since 1884. The nitrogen materials under comparison are applied in such quantities as to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is used on one plot, nitrate of soda on two, sulfate of ammonia on three and dried blood on two.

The plots to which nitrogen has been applied in the form of sulfate of ammonia have shown a tendency to comparative unproductiveness, due without doubt to unfavorable chemical or biological conditions. These unfavorable conditions have apparently tended to prevent or to retard the nitrification of the ammonia nitrogen. As a means of correcting the faulty conditions, 50 pounds of unslaked lime were applied to plot

6 in 1896. Twice since that date, in 1898 and in 1905, the entire field has been limed, as observation of the growth of the crops, especially of clover, indicated that liming would be beneficial. In 1898, lime was applied at the rate of 2,000 pounds per acre of air-slaked lime. In 1905, 2,395 pounds of slaked lime were applied to the entire field, this being at the rate of a little more than a ton to the acre.

The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas.

The crop of the past season was Rustler White Dent corn, the seed having been obtained in Minnesota. It may be here remarked that this variety seems to be well adapted to our local soil and climatic conditions. It gave a thoroughly matured crop and a heavy yield.

After the harvest of the crop of the season 1905 (oats and peas), the land was replowed and sown to clover late in August. This clover made a poor start, and was badly injured by the winter. The condition in the spring was best on plot 0 (manure). It was poorest on plots 5 and 6 (sulfate of ammonia). On these there were but few living plants remaining. The condition of the clover being so poor, the field was plowed on May 18. The manure and the fertilizers were applied in accordance with the regular system on May 21. The field was harrowed thoroughly on May 22 and 23; it was planted on the 23d. The crop was thoroughly cared for, and no exceptional conditions likely to interfere with the experiment were noted. The rates of yield on the several plots and the sources of nitrogen on each are shown in the following table: —

Yield of Corn and Stover per Acre.

Plots.	Nitrogen Fertilizers used.	Corn (Bushels).		Stover (Pounds).
		First Quality.	Second Quality.	
0, . .	Barnyard manure, ...	86.71	16.14	6,500
1, . .	Nitrate of soda (muriate of potash), . .	62.14	13.57	6,300
2, . .	Nitrate of soda (sulfate of potash), . . .	70.00	14.00	6,100
3, . .	Dried blood (muriate of potash), . . .	62.43	10.43	6,000
4, . .	No nitrogen (sulfate of potash), . . .	34.29	13.86	6,200
5, . .	Sulfate of ammonia (sulfate of potash), . .	62.57	10.00	5,400
6, . .	Sulfate of ammonia (muriate of potash), .	62.86	9.86	5,350
7, . .	No nitrogen (muriate of potash), . . .	35.00	10.00	5,350
8, . .	Sulfate of ammonia (muriate of potash), .	61.71	12.86	5,930
9, . .	No nitrogen (muriate of potash), . . .	29.29	15.71	5,600
10, . .	Dried blood (sulfate of potash), . . .	57.71	12.57	5,800

The yield on the three no-nitrogen plots (4, 7 and 9) is much inferior to that on any of the others, although it is still almost equal to the average rate of yield of corn per acre in this State. The yield on all the plots receiving nitrogen was good, but wide differences will be noticed. The plot to which manure was applied gave a yield much superior to that obtained on any of the other plots. The relative rank of the manure plot with most of the crops grown has been much lower. In corn, as is well understood, we have a crop capable, in unusual degree, of utilizing the nitrogen of our coarser manures, since its principal growth occurs at a season sufficiently late so that the nitrogen of the comparatively inert organic compounds of the manure can previously have been rendered available by the natural processes of decay and nitrification, for which the warm weather of the early and mid-summer months is so favorable.

The average yields of this year on the several fertilizers are shown in the following table: —

Fertilizers used.	Corn (Bushels).		Stover (Pounds).
	First Quality.	Second Quality.	
Average of no-nitrogen plots (4, 7, 9),	32.86	13.19	5,717
Average of the nitrate of soda plots (1, 2),	66.07	13.79	6,200
Average of the dried blood plots (3, 10),	60.07	11.50	5,900
Average of the sulfate of ammonia plots (5, 6, 8),	62.38	10.90	5,560

As a result of all the experiments previous to this year, it has been found that the materials furnishing nitrogen have produced crops in the following relative amounts: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.47
Dried blood,	91.09
Sulfate of ammonia,	88.83
No nitrogen,	71.52

Similar averages for this year are as follows: —

	Per Cent.	
	Corn.	Stover.
Nitrate of soda,	100.00	100.00
Barnyard manure,	131.24	104.83
Sulfate of ammonia,	94.41	89.68
Dried blood,	90.92	95.16
No nitrogen,	49.73	92.20

If we combine the results showing relative standing in 1906 with the similar figures for all the years previous to 1906, the relative standing is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.63
Dried blood,	91.08
Sulfate of ammonia,	89.14
No nitrogen,	70.24

All the figures showing relative standing included in the above tables are based upon the total yields. Presented in this way, they are not without interest. Of even greater interest, however, will be a comparison on the basis of the increases as compared with the no-nitrogen plots, due to the

different nitrogen-containing materials which have been used. On this basis, increase in crop, rather than on the basis of total product, the manure and fertilizers used as a source of nitrogen rank to date for the entire period of the experiment, 1890 to 1906, inclusive, as follows: —

Relative Increases in Yields (Averages for the Seventeen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	85.32
Dried blood,	70.03
Sulfate of ammonia,	63.51

It will be noticed that, whatever the basis of comparison, the nitrate of soda has on the average given results considerably superior to those obtained either with manure or with either of the other nitrogen fertilizers. It will also be noticed that the sulfate of ammonia, on the other hand, has given results much inferior to those obtained with either of the other materials supplying nitrogen. If nitrogen, then, can be purchased in the form of nitrate at a price per unit not exceeding that which it will cost in other forms, there can be little doubt that it should be depended upon as a source of this element for most of the crops of the farm. The results of the past season, however, indicate that, as would naturally be anticipated, the nitrate does not show the same degree of superiority for corn as has usually been shown with the crops raised in this field, almost all of which complete their growth at a much earlier date in the season than corn.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

In this experiment, muriate of potash is compared with the high-grade sulfate on the basis of such applications as will furnish equal actual potash per acre. These potash salts are used in connection with bone meal at the rate of 600 pounds per acre. The experiment was begun in 1892. During the first eight or nine years, potash salts were applied in varying quantities, but for the most part at the rate of about 350 to 400 pounds per acre. Since 1900, each has

been applied annually at the rate of 250 pounds per acre. There are ten plots in the field, each containing about one-seventh of an acre. Five of these plots receive muriate of potash, and these plots alternate with the same number of plots which are yearly manured with sulfate of potash.

A large variety of crops has been grown in the different years during which this experiment has continued. The crops of the past year were asparagus, rhubarb, raspberries, blackberries, mixed hay, potatoes and soy beans. On each of plots 13 and 14 four different perennial crops are grown, namely, asparagus, rhubarb, raspberries and blackberries, each crop occupying substantially one-quarter of the area. The hay crop occupied four plots, the potatoes and soy beans two each.

No accidental conditions were observed which unfavorably influenced any of the crops. It is believed that the differences shown by the table giving the yields are due to the difference in potash salt employed. The rates of yield per acre of the various crops on the different fertilizers are presented in the following table: —

Crops.	Fertilizer used.	Plots.	Yield per Acre.	
			Beans.	Straw.
Soy beans,	Muriate of potash,	11	23.83 bush.	2,419 lbs.
	Sulfate of potash,	12	28.44 bush.	2,887 lbs.
Asparagus,	Muriate of potash,	13	2,649.7 lbs.	
	Sulfate of potash,	14	1,730.3 lbs.	
			Stalks.	Leaves.
Rhubarb,	Muriate of potash,	13	23,999 lbs.	20,733 lbs.
	Sulfate of potash,	14	40,992 lbs.	33,148 lbs.
Raspberries,	Muriate of potash,	13	57.26 lbs.	
	Sulfate of potash,	14	151.82 lbs.	
Blackberries,	Muriate of potash,	13	266.00 lbs.	
	Sulfate of potash,	14	857.90 lbs.	
			Hay.	Rowen.
Hay,	Muriate of potash,	15	2,438 lbs.	2,000 lbs.
	Sulfate of potash,	16	2,261 lbs.	1,911 lbs.
Hay,	Muriate of potash,	17	2,045 lbs.	1,981 lbs.
	Sulfate of potash,	18	2,709 lbs.	2,046 lbs.
			Large.	Small.
Potatoes,	Muriate of potash,	19	158.1 bush.	25.2 bush.
	Sulfate of potash,	20	180.8 bush.	28.5 bush.

Soy Beans. — The yield of soy beans, as will be noticed, was considerably larger upon the sulfate of potash. We have now carried through a similar experiment with soy beans fifteen times. In seven of these trials the result has been favorable to the sulfate of potash, and in one it was the same on the two salts. The average of all trials is favorable to the sulfate, and it would seem that there can be little doubt that where the two potash salts are continuously used the sulfate rather than the muriate should be selected. The superiority in yield on the former is usually much more than sufficient to cover the small additional cost of that salt, as compared with the muriate.

Asparagus. — It will be noticed that the yield of asparagus on the muriate of potash is more than 50 per cent. greater than on the sulfate. This result in so far as it goes appears to furnish evidence that the customary practice of depending largely upon the muriate as a source of potash for the asparagus crop is sound.

Rhubarb. — The yield of rhubarb this year is much larger than in any preceding year during which this crop has been grown in this experiment. In the earlier years the yield on the sulfate of potash has been moderately greater than on the muriate; this year it is very much greater, exceeding the yield on the muriate by about 80 per cent. Should further experiment support the evidence afforded thus far by this, it would appear that rhubarb growers in general will be wise to depend upon the sulfate rather than the muriate as a source of potash for that crop.

Raspberries and Blackberries. — The yield of both these crops is small on both fertilizers, that of raspberries especially so. During the three or four years the experiment on these plots has continued, the sulfate has invariably given better results than the muriate. Particularly noticeable has been the difference in the degree of winter-killing. The canes upon the plot to which muriate of potash is applied seem to be much less hardy than those on the plot where sulfate is used; and, with little doubt, the greater yield on the latter potash salt is mainly a consequence of the fact that the injury due to winter-killing is so much less.

Should further experiment confirm what now appears to be probable in regard to the varying effect of these two potash salts upon the ability of the canes of these fruits to resist the winter's cold, the point demonstrated will be one of much importance, for winter-killing is one of the most serious obstacles to the successful production of some of the most desirable varieties of these fruits.

The Hay Crops. — The hay crop of the past year occupied four plots. Clover seed alone was sown, but the clover did not make a good stand, and the vacancies were filled in part by timothy, in part by weeds. Where the clover was best, a considerable superiority in favor of the sulfate of potash was manifest. Aside from this observation, the results of the year with the hay crop did not appear to have much significance.

Potatoes. — It will be noted that the yield of merchantable potatoes upon the sulfate of potash was materially larger than on the muriate. This result is in accordance with the results which have usually been obtained in experiments upon our grounds; and, in spite of the fact that the season during which the potatoes made their chief growth was this year characterized by a considerable deficiency of rainfall, the soil where the sulfate has been continuously used shows its superiority over that where the muriate has been similarly used.

III. — Comparison of Different Potash Salts for Field Crops. (Field G.)

This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash salts which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual

potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.

The crops which have been grown in this field in the order of their succession beginning in 1898 have been as follows: —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cowpeas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.
1906. Potatoes.

The results last year with the soy bean seemed rather inconclusive, on account of the number of variations due to exceptional conditions not necessarily connected with the varying use of potash salts. In brief, it may be stated that the plots to which kainit was applied gave the smallest average crops in the field, the yield being less even than on the no-potash plots. Carbonate of potash gave the highest average yield, followed closely by high-grade sulfate and silicate, while the yields on nitrate, muriate and low-grade sulfate were not much inferior.

The crop of the past season was potatoes. The variety grown was the Green Mountain, the seed having been purchased in Maine. One accidental variation must here be recorded, viz., that the quantity of Green Mountain seed proved to be slightly less than was needed, so that it was necessary to use another variety, Carmen No. 3, also from Maine, on one of the plots (40). The seed potatoes were treated with formalin at the rate of 1 pint to 15 gallons of water in the usual way on May 7. The field was plowed on May 8. On May 10, 2,427 pounds of freshly slaked lime were applied. This was harrowed in on May 11. On May 12, fertilizers were applied and harrowed in on the same day. On the same date, also, one-half the plots, four series, 1-20, were

planted. On May 14, the balance of the field was planted. The crop was carefully cared for throughout the entire season. The vines were repeatedly sprayed with Bordeaux mixture, and carefully protected from bugs by the customary measures. Early in the season the vines on the no-potash plots showed a marked inferiority in growth. They were characterized by a dark, bluish-green color. The vines on the plots receiving chlorides in any form showed a distinctly lighter shade of green (pea green) than those manured with other potash salts. The vines on the silicate of potash plots were very dark in color, and somewhat resembled in general appearance, though much larger in growth, the vines on the no-potash plots.

The yields per plot and the rates of yield per acre are shown in the following table: —

Plots.	Potash Salt.	Pounds per Plot.		Bushels per Acre.	
		Large.	Small.	Large.	Small.
1, . .	No potash, ...	305.25	106.50	203.50	71.00
2, . .	Kainit, ...	424.75	83.75	283.16	55.83
3, . .	High-grade sulfate, ...	428.50	74.50	285.66	49.66
4, . .	Low-grade sulfate, ...	407.00	65.00	271.33	43.33
5, . .	Muriate, ...	439.75	74.00	293.16	49.33
6, . .	Nitrate, ...	412.75	71.50	275.16	47.66
7, . .	Carbonate, ...	374.25	94.50	249.50	63.00
8, . .	Silicate, ...	362.25	63.75	241.50	42.50
9, . .	No potash, ...	280.25	45.00	186.83	30.00
10, . .	Kainit, ...	340.00	47.00	226.66	31.33
11, . .	High-grade sulfate, ...	351.00	49.00	234.00	32.66
12, . .	Low-grade sulfate, ...	360.25	47.25	240.66	31.50
13, . .	Muriate, ...	332.50	53.00	221.66	35.33
14, . .	Nitrate, ...	350.75	37.00	235.50	24.66
15, . .	Carbonate, ...	313.50	76.00	209.00	50.66
16, . .	Silicate, ...	337.75	58.50	225.16	39.00
17, . .	No potash, ...	172.50	44.50	115.00	29.66
18, . .	Kainit, ...	231.25	33.25	154.16	22.66
19, . .	High-grade sulfate, ...	267.00	38.00	178.00	25.33
20, . .	Low-grade sulfate, ...	247.50	36.75	166.66	24.50
21, . .	Muriate, ...	269.50	40.00	179.66	26.66
22, . .	Nitrate, ...	241.50	55.50	161.00	37.00

Plots.	Potash Salt.	Pounds per Plot.		Bushels per Acre.	
		Large.	Small.	Large.	Small.
23, . .	Carbonate, ...	252.25	81.25	168.66	54.16
24, . .	Silicate, ...	235.25	61.25	156.83	40.33
25, . .	No potash, ...	135.50	50.50	90.33	33.66
26, . .	Kainit, ...	264.75	29.00	176.50	19.33
27, . .	High-grade sulfate, ...	278.75	35.50	185.83	23.66
28, . .	Low-grade sulfate, ...	330.25	36.25	220.16	24.16
29, . .	Muriate, ...	320.25	47.50	213.50	31.66
30, . .	Nitrate, ...	285.75	58.75	190.50	39.16
31, . .	Carbonate, ...	335.00	76.50	223.33	51.00
32, . .	Silicate, ...	254.25	74.25	167.83	49.50
33, . .	No potash, ...	167.00	46.00	111.33	30.66
34, . .	Kainit, ...	292.00	39.00	194.66	26.00
35, . .	High-grade sulfate, ...	307.25	41.00	204.83	27.33
36, . .	Low-grade sulfate, ...	310.00	44.00	206.66	29.33
37, . .	Muriate, ...	315.75	73.00	210.50	48.66
38, . .	Nitrate, ...	321.75	49.00	214.50	32.66
39, . .	Carbonate, ...	298.25	70.00	198.83	46.66
40, . .	Silicate, ...	312.00	59.00	208.00	39.33

The average yields under the varying fertilizer treatments are as follows: —

Potatoes. — Average Yields per Acre (Bushels).

Potash Salt.	Large.	Small.
No potash (plots 1, 9, 17, 25, 33), ...	141.40	39.00
Kainit (plots 2, 10, 18, 26, 34), ...	207.03	31.03
High-grade sulfate (plots 3, 11, 19, 27, 35), ...	217.66	31.73
Low-grade sulfate (plots 4, 12, 20, 28, 36), ...	221.09	30.56
Muriate (plots 5, 13, 21, 29, 37), ...	223.70	38.33
Nitrate (plots 6, 14, 22, 30, 38), ...	215.33	36.23
Carbonate (plots 7, 15, 23, 31, 39), ...	209.86	53.10
Silicate (plots 8, 16, 24, 32, 40), ...	199.86	42.13

It will be noticed that the no-potash plots on the average give a yield much inferior to that produced on the plots receiving potash. The best average yield is produced by the muriate, but the differences between the yield on this potash

salt and the average yield produced by the low-grade and high-grade sulfate and the nitrate are small. Carbonate ranks next, followed by kainit and silicate. The past season (June 1 to August 15) was characterized by rainfall considerably below the average. Previous experiments have shown that in such seasons muriate of potash can usually be depended upon to give crops equal to those produced where the sulfates are used. Lime, moreover, is known to offset in a measure the unfavorable results consequent upon continued use of muriate; and the entire field, as stated, was limed this season.

We are unable at this time to make a report in relation to the quality of the tubers produced on the different fertilizers, but the different lots have been carefully sampled, and such a report will be made later.

The Effect of the Liming. — Attention is called to the fact that in using lime immediately preceding the potato crop we departed from the usually accepted rule. Such use of lime is not regarded as desirable on account of the chances that the immediately following crop of potatoes will be scabby. This result was noted upon a portion of the plots in this field, principally 1 to 8. The amount of scab, however, was not on the whole serious.

The Relation of the Potash to Potato Blight. — As has been stated in the description of the general care given the crop, the potatoes in this field were repeatedly and carefully sprayed with Bordeaux mixture. The dates of the successive applications were as follows: June 27, July 7, August 2–3, August 10. Early in August it was noticed that the leaves of all the no-potash potato plants were beginning to blight, while the foliage on all the plots to which potash has been annually applied still appeared to be practically unaffected. The blight made rapid progress on each of the five no-potash plots, while the foliage of the vines upon all the other plots for the most part ripened normally. Practically all the leaves on the no-potash plots were dead by the end of August, at which date there was still considerable living foliage on the other plots. There was no decay of the tubers, however, on any of the plots; but the marked inferiority in

yield on the no-potash plots was no doubt in considerable measure due to the relatively early death of the foliage.

No explanation can be offered at this time for the observed phenomena. Earlier observers, among them Dr. Goessmann and Professor Maynard, have held that a liberal supply of potash has in some cases exercised a marked influence in enabling the foliage of fruits to resist fungous diseases. Some European investigators have attributed a similar effect to potash in connection with potato diseases. This matter should evidently receive further and most careful study, for, if potato blight can be in a measure controlled through more liberal use of potash salts, this will afford a comparatively easy method of reducing the amount of injury due to the fungi attacking the foliage of this important crop.

IV. — North Corn Acre. — Special Fertilizer *v.* Fertilizer richer in Potash.

This experiment was begun in 1891. It occupies an acre of ground, divided into four equal plots. Plots 3 and 4 were sown to millet during the first two years of the experiment, but with this exception their treatment has been the same as that of plots 1 and 2, 3 being a duplicate of 1, and 4 a duplicate of 2, both as regards fertilizer application and crops produced. During the period under consideration the entire area with the exception noted for plots 3 and 4, has been in corn, with the exception of three two-year periods, 1897 and 1898, 1899 and 1900, and the past two years, during which periods the land has been in mixed grass and clover. The method of seeding in every instance has been by sowing in the corn of the year preceding the first of each of the three two-year periods during which hay has been the crop.

The object in this experiment is to test the question whether the special corn fertilizers offered in our markets are of such composition as seems to be best suited for the production of corn and mixed hay in rotation. Plots 1 and 3 have yearly received an application of fertilizers (a home mixture) furnishing per acre the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer having the composition of the average of the spe-

cial corn fertilizers analyzed at this station. This average changes but little from year to year, and in 1899, since which date we have made no change in the kinds and amounts of fertilizers used, it was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The averages for the past year have been: nitrogen, 2.61 per cent.; phosphoric acid, 11.55 per cent.; and potash, 4 per cent.

The fertilizers which have been used on plots 2 and 4 are substantially the same in amount and kind as were recommended for corn in Bulletin No. 58 (Hatch). The essential difference in the fertilizer mixtures under comparison is that the mixture used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. The difference in the application of the fertilizer elements is shown in the following table: —

Fertilizer Elements applied annually.

Plots.	Rates per Acre (Pounds).		
	N	P_2O_5	K_2O
Plots 1 and 3,	42.6	180	77.4
Plots 2 and 4,	47.0	50	125.0

The fertilizer materials applied to the several plots annually are shown below: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	-
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

This field was limed in 1900 at the rate of 1 ton to the acre.

The crop of the past season was mixed grass and clover, the present being the second year for this seeding. The rates of yield per acre on the several plots and the averages for the two systems of manuring are shown by the following tables: —

Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (lesser potash),	2,600	1,680
Plot 2 (richer in potash),	2,320	1,480
Plot 3 (lesser potash),	2,980	1,300
Plot 4 (richer in potash),	2,400	2,020

Average Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3 (lesser potash),	2,790	1,490
Plots 2 and 4 (richer in potash),	2,360	1,750

It will be noticed that the combination of fertilizers representing the special corn fertilizer gives an average yield of hay at the rate of 430 pounds per acre heavier than that produced where the combination of fertilizer materials richer in potash was used. On the other hand the latter combination of fertilizer materials gives a yield of rowen averaging 260 pounds per acre greater than the special corn fertilizer. The total crops, then, produced under the two systems of fertilizing, are not far from equal for the past year.

Since this experiment was begun, this land has produced on plots 1 and 2, ten corn crops; on plots 3 and 4, eight corn crops. The average yields per plot and the averages for the two systems of fertilizing are shown in the following tables: —

Average Yields of Corn per Acre.

Plots.	Corn (Bushels).	Stover (Pounds).
Ten Years.		
Plot 1 (lesser potash),	56.77	4,596
Plot 2 (richer in potash),	51.98	4,640
Eight Years.		
Plot 3 (lesser potash),	55.18	4,371
Plot 4 (richer in potash),	52.99	4,590

Average Yields per Acre on the Two Systems of Fertilizing.

Plots.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	55.98	4,484
Plots 2 and 4 (richer in potash),	52.48	4,615

During the period of this experiment the entire field has produced six crops each of hay and rowen. The averages for each plot and the averages for the two systems of fertilizing are shown in the following tables: —

Average Yields per Acre of Hay and Rowen, Six Years (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (lesser potash),	3,655	1,100
Plot 2 (richer in potash),	3,785	1,176
Plot 3 (lesser potash),	3,459	885
Plot 4 (richer in potash),	3,607	1,203

Average Yields per Acre on the Two Systems of Fertilizing, Six Years (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3 (lesser potash),	3,557	993
Plots 2 and 4 (richer in potash),	3,696	1,152

It will be noticed that the average crop of corn has been somewhat heavier, while the average crop of hay is slightly

less, on the combination of materials representing the special corn fertilizer. The crops of corn stover and of rowen have been greater on the combination of materials furnishing more potash. This is in accordance with what is to be expected, as the potash is found almost invariably to favor a large proportion of clover in mixed mowings, and as it has been shown in the results of many experiments in this State that stover is increased in larger proportion through application of potash than is the grain.[1]

At the prices which have prevailed during the period of the experiment, the cost per acre of the fertilizers used on plots 2 and 4 has averaged about $5 less than the cost of the materials used on plots 1 and 3. Taking the crops as a whole, they have been substantially equal under the two systems of fertilizing; and the advantage, therefore, is clearly with the fertilizer combination richer in potash, unless it can be shown that the condition of the soil upon plots 2 and 4 is now inferior to that of the soil on plots 1 and 3. Such inferiority is not indicated by the present relative yields. Neither does a study of the income and outgo from the soil of fertilizer elements upon the several plots point in that direction. Calculations made at the close of 1905 to determine the fertilizer ingredients supplied and removed from the several plots gave the following results: —

Plots.	Fertilizer Ingredients.					
	Supplied.			Removed.		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Plot 1 (lesser potash),	135.10	537.94	216.00	331.08	117.74	228.46
Plot 2 (richer in potash),	117.55	217.63	470.00	322.44	114.32	229.79
Plot 3 (lesser potash),	135.10	537.94	216.00	259.52	93.37	180.26
Plot 4 (richer in potash),	117.55	217.63	470.00	307.38	109.97	234.27

A study of the figures of the above table indicates that on every plot a much larger quantity of nitrogen has been removed from the soil than has been supplied in the fertilizers used. The large excess of nitrogen removed can be

[1] Bulletin No. 9 and Bulletin No. 14, Hatch Experiment Station.

accounted for only as a result of the frequent introduction of clover in the rotation.

It will be noticed that on plots 1 and 3 phosphoric acid has been applied in the fertilizers used in quantity on the average more than five times greater than the quantity removed. Even on plots 2 and 4 phosphoric acid has been supplied in quantity practically double that removed.

Potash on one of the plots (1 and 3) has been supplied in slightly larger quantity than removed, while on the other plot the quantity removed is slightly in excess of the quantity supplied.

On the average, the condition of the soil as regards this element on plots 1 and 3 cannot be materially different from what it was at the beginning of the experiment. On plots 2 and 4, on the other hand, potash has been supplied in quantity a little more than double that removed.

V. — South Corn Acre. — Manure Alone *v.* Manure and Potash.

The object in view in this experiment is to compare the crop-producing capacity of manure alone applied in fairly liberal amounts with a combination of a lesser amount of manure and a moderate quantity of a potash salt. An acre of land is used in the experiment. It is divided into four plots, of one-quarter acre each. Two of the plots (1 and 3) have received applications of manure only; the other two plots (2 and 4) have been fertilized by applications of lesser amounts of manure, together with a potash salt.

This experiment was begun in 1891. The crop for the first six years was corn. Corn was raised also in 1899 and 1900, and in 1903 and 1904. The field has been put into mixed grass and clover three times, being seeded in the summer preceding the first year of cutting in the corn crop. Each time that the land has been seeded it has been cut twice annually for two years. The sod has then been broken in the fall for the corn crop of the following year. The years when the field has been in mowing are 1898 and 1899, 1901 and 1902, and 1905 and 1906.

Manure has been applied to plots 1 and 3 every year, at

the rate of 6 cords per acre, with the following exceptions. No manure was applied in 1897, 1902 and 1905, and in 1898 the amount applied was at the rate of 4 cords per acre. The reason for the omission of manure in the years mentioned and for the smaller amount in 1898 was that experience indicated that its application would cause the grass and clover to lodge badly.

Manure has been applied to plots 2 and 4 as follows: in 1891 and 1892, at the rate of 3 cords per acre; in 1898, at the rate of 2 cords per acre; while in 1897, 1902 and 1905 no manure was applied. In all other years the application has been at the rate of 4 cords per acre. Potash has been applied to plots 2 and 4 at the rate of 160 pounds per acre of high-grade sulfate annually, except in the years when no manure was applied. In these years the potash also was withheld.

The entire field was limed in 1900, at the rate of 1 ton per acre. The manure applied has been that made by well-fed milch cows, and carefully preserved. It has usually weighed about 3 tons per cord. Both manure and fertilizer have been applied broadcast after plowing, and harrowed in.

The crop of the past season was mixed grass and clover, this being the second year, as above indicated. The manure was applied with a spreader on May 2. The high-grade sulfate was applied broadcast by hand, and this year, by mistake, it was applied to plots 1 and 3 as well as to plots 2 and 4.

The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields Per Acre, 1906 (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (manure alone),	3,880	2,640
Plot 2 (manure and potash),	3,200	2,384
Plot 3 (manure alone),	3,592	2,396
Plot 4 (manure and potash),	3,180	2,416

Average Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3 (manure alone), ...	3,736	2,518
Plots 2 and 4 (manure and potash), ...	3,190	2,400

It will be noticed that the hay crop on the combination of manure and potash is less than on the larger quantity of manure alone in both cases, the average difference being at the rate of 646 pounds per acre. The rowen crops are more nearly equal, the average difference amounting to only 118 pounds per acre in favor of the larger application of manure. The heavier application of manure means, of course, a larger application of nitrogen. It is not surprising, therefore, that the first crop, which includes a considerable proportion of timothy and redtop, is heavier where the manure is most largely used. The rowen crop is made up in much larger proportion of clover, and the proportion of clover is greater where the lesser quantity of manure and the potash salt are applied. Estimating the manure to cost on the land $5 per cord and the high-grade sulfate of potash at the market rates, the usual annual difference in cost of materials applied has amounted to about $6 to $6.50 per acre, the lesser amount of manure and potash costing about that amount less than the larger application of manure.

This experiment has now continued sixteen years. During this time ten corn crops have been raised. The average yields per plot and the averages for the two systems of manuring are shown in the following tables: —

Average Yields per Acre.

Plots.	Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone), ...	62.32	4,929
Plot 2 (manure and potash), ...	58.48	4,579
Plot 3 (manure alone), ...	61.29	4,292
Plot 4 (manure and potash), ...	57 54	4,104

Average Yields per Acre on the Two Systems of Manuring, Ten Crops.

Plots.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone), ...	61.81	4,611
Plots 2 and 4 (manure and potash), ...	58.01	4,342

It will be noticed that the average yield on plots 2 and 4 (lesser manure and potash) has been at the rate of about 3.8 bushels per acre less than on the larger quantity of manure alone.

During six years the experimental acre has been in mixed grass and clover. The following tables show the average results per plot and the averages for the two systems of manuring: —

Average Yields per Acre of Hay Crop, Six Years (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (manure alone), ...	5,197	2,569
Plot 2 (manure and potash), ...	4,370	2,103
Plot 3 (manure alone), ...	4,970	2,546
Plot 4 (manure and potash), ...	4,923	2,415

Average Yields per Acre on the Two Systems of Manuring, Six Years (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3 (manure alone), ...	5,084	2,558
Plots 2 and 4 (manure and potash), ...	4,647	2,259

It will be noticed that the average difference against the lesser quantity of manure and potash amounts to a little more than 400 pounds of hay and slightly less than 300 pounds of rowen per acre annually.

The differences indicated by the averages shown in the above tables, whether for corn or hay, are not sufficient to offset the greater cost of the heavier application of manure.

At the end of last year, calculations based in part upon analyses, and in part upon average figures for the composition of the crops raised, gave results presented in the following tables for the totals of plant food applied and removed in the several plots: —

Plots.	Fertilizer Ingredients.					
	Supplied.			Removed.		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Plot 1 (manure alone), ...	425.41	330.69	511.51	394.07	138.74	282.60
Plot 2 (manure and potash), . .	291.09	229.98	543.68	361.22	127.91	256.64
Plot 3 (manure alone), ...	449.96	330.94	500.76	373.34	132.10	262.21
Plot 4 (manure and potash), . .	281.10	233.37	549.56	355.02	126.26	250.82

It will be noticed that on plots 1 and 3 the amounts of nitrogen applied in the manure show a moderate excess above the amount removed in the crops. On the other hand, the application of nitrogen to plots 2 and 4 (lesser manure and potash) is materially less than the amount removed. This result may have been rendered possible in one of two ways: first, the soil on these plots may have been depleted in part of its original store of nitrogen; second, the excess may have been taken from the air by the clover in the mixed hay crops grown during six of the sixteen years. As these plots show no indication of declining fertility, but, on the contrary, appear on the whole to be improving from year to year, the latter is with little doubt the correct explanation.

It will be noticed that under both systems of manuring we have applied phosphoric acid and potash in large excess above the amounts removed. In the case of plots 1 and 3, phosphoric acid has been applied in approximately two and one-half times the quantity removed; potash, in rather less than twice the quantity removed. In the case of plots 2 and 4, phosphoric acid has been applied in considerably less than twice the quantities removed; potash, in rather more than twice the quantities removed. In view of the fact that neither phosphoric acid nor potash is supposed to be lost to the soil to any considerable extent by leaching, the condition of the soil on all the plots as regards the stock of phosphoric

acid and potash in available form must now be considerably better than at the beginning of the experiment; and there can be little doubt that a lesser application of these fertilizer elements in the immediate future will prove sufficient to give satisfactory crops.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The past season is the tenth of this experiment, the object of which is to determine, as measured by crop production, the relative availability of different materials which may be used as sources of phosphoric acid. All these materials have from the first been applied in such quantities as to furnish phosphoric acid at the rate of 96 pounds per acre in the case of each of the materials under comparison. The field comprises thirteen plots, each containing one-eighth of an acre. Three of the plots have received no phosphoric acid since the experiment began. One of these is located at either end of the field, the third in the middle. The phosphates under comparison are the following: apatite (fine ground), South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. Materials supplying nitrogen and potash liberally are applied to each of the plots annually, and in such quantities as to furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. In the case of a few crops requiring especially high manuring (onions and cabbages), a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. Owing to the impossibility of procuring the material, no apatite was applied to plot 2 during the past season. The crops which have been grown in the field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, cabbages, and mixed grass and clover. The field was seeded in the spring of 1905 without a nurse crop. It was cut twice during the season, but the product, largely mixed with weeds, was not weighed.

During the past season the field has been cut twice and the product made into hay. The following table gives the yield per plot, the rates of yield per acre, and the gain or loss as compared with the no-phosphate plots, both for the hay and rowen: —

Plots.	Fertilizers used.	Yield per Plot (Pounds).		Yield per Acre (Pounds).		Gain or Loss (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
Plot 1, .	No phosphate, ...	825	225	6,600	1,800	-	-
Plot 2, .	Apatite, ...	940	215	7,520	1,720	800	—147
Plot 3, .	South Carolina rock phosphate.	930	202	7,440	1,616	720	—251
Plot 4, .	Florida soft phosphate, .	950	188	7,600	1,504	880	—363
Plot 5, .	Phosphatic slag, . .	950	200	7,600	1,600	880	—267
Plot 6, .	Tennessee phosphate, .	890	203	7,120	1,624	400	—243
Plot 7, .	No phosphate, ...	875	275	7,000	2,200	-	-
Plot 8, .	Dissolved bone black, .	870	280	6,960	2,240	240	+373
Plot 9, .	Raw bone, ...	890	250	7,120	2,000	400	+133
Plot 10, .	Dissolved bone meal, .	940	319	7,520	2,552	800	+685
Plot 11, .	Steamed bone meal, . .	890	283	7,120	2,264	400	+397
Plot 12, .	Acid phosphate, . .	885	290	7,080	2,320	360	+453
Plot 13, .	No phosphate, ...	820	200	6,560	1,600	-	-

It will be noticed that both the first and second crops of hay were heavy, the first especially so. This crop had lodged considerably before it could be cut, and there is little doubt that the possible increase due to the fertilizers was somewhat diminished through the check in growth consequent upon the badly lodged condition. We do not find the application of the phosphates to have apparently influenced the yield either of hay or rowen to a very large extent. The results are in harmony with previous observations upon our soils, which have indicated them to require relatively small applications of phosphates for all crops except those belonging to the Cruciferæ, such as cabbages and turnips. In 1903, when this entire field was planted to cabbages, the yields wherever phosphates were annually applied greatly exceeded the average yield on the no-phosphate plots. The range on the several phosphate plots was from about two to five times the average product of the no-phosphate plots. This year,

with a mixed crop, grass and clover, representing Gramineæ and Leguminosæ, the largest increase on any phosphate is only about 17 per cent. In other words, when cabbages were the crop, the increase was in some instances as great as 500 per cent., or nearly thirty times as great as this year.

VII. — Soil Tests.

Two soil tests have been carried out during the past year, both in continuation of previous tests upon the same fields. In these tests fertilizers have been applied in accordance with the co-operative plan for soil tests. Each plot annually receives an application of the same kind or kinds of fertilizers, and usually in the same amounts for each of the plots from year to year. Particular attention is called to the fact that this system of fertilization is not expected to secure the production of heavy crops. It does throw important light upon the specific effects of the different leading elements of plant food by themselves and in combination on the crops which are grown in succeeding years. Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities; and both fertilizers and manure, when the latter is introduced for purposes of comparison, are always applied broadcast after plowing, and harrowed in when a hoed crop is to be grown. When mixed hay is the crop the materials are applied broadcast, and must of course be left on the surface. The kinds of fertilizers and the rates per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 800 pounds.
Manure, 5 cords.

The germination of the soy beans on the north acre was very irregular. The stand of plants as a consequence was so uneven that the results do not indicate with any clearness the effect of the different fertilizers. The figures will not, therefore, be reported in detail. The results, however, clearly

indicated the beneficial results which have followed the use of lime in connection with the other fertilizers.

Soil Test with Corn (South Acre). — This acre has been used in soil tests for eighteen years, beginning in 1889. The field has been limed twice during this period, each time at the rate of 1 ton to the acre. The lime was applied broadcast after plowing, and harrowed in. These applications of lime were made respectively in 1899 and in 1904.

The crops for successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover. Since 1899 this field has, therefore, borne eight corn crops. Three times it has been put into mixed grass and clover, each time for two years. The past season is the second of the third two-year period. The season has been a fairly favorable one for grass, although, as the soil of this field is inclined to be light, there can be no doubt that a somewhat heavier yield would have been obtained had the rainfall been larger. The following table shows the fertilizers used on the several plots, the rates of yield and the gain or loss per acre, compared with the nothing plots: —

Grass and Clover. — South Acre Soil Test, 1906.

Plots.	Fertilizers used.	Yield per Acre (Pounds).		Gain or Loss per Acre, compared with Nothing Plots.	
		Hay.	Rowen.	Hay.	Rowen.
Plot 1, .	Nitrate of soda, ...	1,400	520	+490.0	+220.00
Plot 2, .	Dissolved bone black, . . .	760	295	—150.0	—5.00
Plot 3, .	Nothing, ...	910	300	-	-
Plot 4, .	Muriate of potash, ...	690	440	—136.7	+131.70
Plot 5, .	Lime, ...	890	260	+146.7	—56.70
Plot 6, .	Nothing, ...	660	325	-	-
Plot 7, .	Manure, ...	2,940	2,670	+2,226.7	+2,323.30
Plot 8, .	Nitrate of soda and dissolved bone black.	2,200	520	+1,433.3	+151.70
Plot 9, .	Nothing, ...	820	390	-	-
Plot 10, .	Nitrate of soda and muriate of potash.	2,400	470	+1,536.7	+73.33
Plot 11, .	Dissolved bone black and muriate of potash.	1,790	1,220	+883.3	+816.70
Plot 12, .	Nothing, ...	950	410	-	-
Plot 13, .	Plaster, ...	640	320	—310.0	—90.00
Plot 14, .	Nitrate of soda, dissolved bone black and muriate of potash.	3,000	1,100	+2,050.0	+1,690.00

It will be noticed that the yield on all the nothing plots is extremely small, — considerably less than one-half ton per acre. It will be noticed, further, that neither lime nor plaster used by itself produced an increase; indeed, the yield on both is lower than the average yield of the nothing plots. Nitrate of soda by itself produces a very small increase; in combination with either of the other fertilizer elements the increase is much larger, but it is best, as would naturally be expected, in combination with both the other fertilizer elements. It will be noted that the use in combination of dissolved bone black and muriate of potash gives a considerable increase in the crop. This increase shows itself almost as plainly in the rowen as in the first crop, as a consequence, of course, of the relatively large proportion of clover which follows continuous use of materials supplying phosphoric acid and potash without nitrogen. The average results obtained in the six years during which this field has been in hay will be of interest. They are shown in the following table: —

Average Increases in Six Hay and Rowen Crops.

	Averages of Nothings.	Nitrate.	Bone Black.	Muriate.	Lime.	Manure.
Hay, ...	853.8	722.5	— 100.0	152.6	120.0	2,579.2
Rowen, ...	604.4	743.3	+ 52.5	632.0	108.8	2,357.2
Totals, . . .	1,458.1	1,465.8	— 47.5	784.5	228.8	4,936.4

Average Increases in Six Hay and Rowen Crops — Concluded.

	Nitrate and Bone Black.	Nitrate and Muriate.	Bone Black and Muriate.	Plaster.	Nitrate, Bone Black and Muriate.
Hay, ...	1,183.3	1,474.2	1,113.3	— 275.5	2,092.5
Rowen, ...	430.3	565.5	952.8	— 221.8	878.3
Totals, . . .	1,513.6	2,039.7	2,066.2	— 497.2	2,970.8

This table affords conclusive evidence that hay can be grown at a profit on fertilizers alone, although naturally the increases produced by the very moderate applications of fertilizers used in this experiment are not equal to those pro-

duced by the annual application of manure. The latter, however, at $5 per cord on the land costs annually at the rate of $25 per acre; the combination of dissolved bone black and muriate of potash costs annually at the rate of about $6 per acre; while the annual application of all three fertilizer elements costs at the rate of about $10 to $11 per acre.

VIII. — Experiment in Manuring Grass Land.

The plan of this experiment, which was begun in 1893, is fully outlined in the sixteenth annual report. From that report I quote: —

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year, fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

The past season, which showed a considerable deficiency in rainfall during the months when a liberal supply of moisture is highly important for the hay crop, was unfavorable to large yields, and the product of the past season falls considerably below the average product for the period of the experiment. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

Fertilizers used.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	2,892	1,063	3,955
Bone and potash,	2,420	1,396	3,816
Wood ashes,	2,932	1,240	4,172

The average for the entire area this year was 4,002 pounds. The average yield of the entire area from 1893 to 1905, inclusive, was 6,572 pounds. Including the crop of the past season, the average for the entire period, 1893 to the present time, is 6,389 pounds. The average yields to date under the different systems of top-dressing have been as follows: —

	Pounds per Acre.
When top-dressed with manure,	6,658
When top-dressed with wood ashes,	6,059
When top-dressed with bone and potash,	6,331

IX. — Experiment in the Application of Manure.

This experiment was planned to be continued through a series of years, with a view to throwing light upon the question as to the best method of handling farm manures. The field in use has an area of a little less than three acres, and slopes moderately to the west. It had been divided into five plots a number of years previous to the beginning of this experiment, for the comparison of different fertilizers. Each of these five plots was subdivided into two sub-plots. To one of these sub-plots in each of the five pairs the manure is applied during the winter, being spread upon the surface as it is hauled to the field; to the other sub-plot in each of the five pairs the manure as it is hauled is put into a large, compact heap. The manure used is carefully preserved, from well-fed dairy cows on four of the pairs of plots (1, 2, 3 and 4), and purchased stable manure from horses on one pair of plots (5). The experiment is so managed that all the manure is hauled for a single pair of plots at one time, usually during a single day, or at most within two days. To insure even quality of the manure on the two sub-plots, loads are placed alternately on the north half, where it is spread as hauled; and on the south half, where, as has been stated, it is put into a large heap. The land has usually been plowed late in the fall. The manure has usually been applied to the two sub-plots 1 early in the winter; to the sub-plots 2, 3 and 4 respectively at intervals each about one month later than the preceding. The manure which is placed in the heaps remains there until it is time to prepare the soil for planting in the spring. It

is then spread, and as soon as convenient the entire area, including both the winter and the spring applications, is plowed. It is estimated that the double handling of the manure required in the case of that portion which is applied in the spring costs at the rate of $4.80 per acre more than the single handling where the manure is spread when hauled during the winter.

The experiment was begun in 1899; the present season, therefore, is the eighth during which the experiment has been continued. The crop of the past season was corn. Fourteen different varieties of seed were used. The different plots, however, were so planted that each contained equal areas of each variety. The fact that a number of varieties was used is mentioned only because it is a partial explanation of the fact that the yield in this field is considerably lower than is usual in this vicinity on well-manured land. This inferiority in yield was due to the fact that many of the varieties which we had been asked to test by the United States Department of Agriculture proved comparatively worthless. The rates of yield per acre and the relative standing of the several plots are shown in the following tables: —

Corn and Stover. — Actual Yields (Rates per Acre).

Plots.	North Half, Winter Application.			South Half, Spring Application.		
	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).
Plot 1,	3,741	36.43	5.86	3,961	38.61	5.65
Plot 2,	3,414	30.50	4.64	3,893	37.48	4.99
Plot 3,	3,563	35.72	5.34	3,847	38.73	5.05
Plot 4,	3,171	32.13	5.01	3,143	29.95	5.61
Plot 5,	3,401	31.22	4.32	3,457	31.91	4.13

Corn and Stover. — Relative Yields (Per Cent.).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Stover.	Hard Corn.	Stover.	Hard Corn.
Plot 1,	100	100	105.7	104.7
Plot 2,	100	100	114.0	122.9
Plot 3,	100	100	107.8	108.4
Plot 4,	100	100	99.1	93.2
Plot 5,	100	100	101.6	102.2

It will be noticed that in every instance the spring application of manure has given a larger yield both of stover and of hard corn than the winter application, except on plot 4. This exception, in our judgment, is due to the fact that during the early part of the season it was comparatively rainy, and a part of the area on the south half of plot 4 was over wet, so that the seed germinated imperfectly. The results of this year, then, although naturally not showing precise numerical agreement, are in entire accord with those obtained in 1905. During the entire period that the experiment has continued the results as a rule have been similar.

It has been noticed that the degree of superiority of the crops on the sub-plots where the manure was spread in the spring has varied with the character of the preceding winter. There is evidently some loss in manurial value through the exposure of the manure throughout the winter, and this loss is probably for the most part due to wash over the frozen ground during the winter or early spring. It has been found that in a season following a cold winter, where snow has covered and protected the manure during practically all the time, and where there has been a minimum of water flowing over the surface, the winter-applied manure has given results closely approaching those upon the manure applied in the spring. It is manifestly impossible to foresee the character of the approaching winter months, and so there must always be a degree of uncertainty as to results. Taken as a whole, however, the differences obtained in our experiments in favor of spring application have been relatively small, and during a large proportion of the time insufficient in value to cover the extra cost of the double handling.

In estimating the significance of our results, it should be kept in mind that the field on which these experiments have been tried has a considerable slope. It is, therefore, of such a character as is favorable to considerable waste through surface wash, whenever the conditions are such as to make such wash possible. It is not believed that on land which is substantially level, and which can be fall plowed, the amount of waste due to the exposure incident to surface application in winter will be sufficiently great to make it good farm

economy to give the manure the double handling involved in the spring application. If the storage for manure is sufficient, so that it can be safely held where made until spring, application at that season will undoubtedly be safest on most of our New England farms, where the surfaces of the fields are usually far from level. With level fields, on the other hand, application of manure during the winter would seem to be the better farm practice.

X. — Nitrate of Soda for Rowen.

The station has been experimenting for a number of years, with a view to noting whether nitrate of soda applied soon after the first crop is cut will give a profitable increase in the rowen crop. The field in which most of our experiments have been tried was seeded to pure timothy in the fall of 1897. The crop is now considerably mixed with clover (mostly white), which has been gradually coming in. For the first crop we apply fertilizers at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds. The total area of the field is a little more than three acres. The rate of yield of the first crop this year was 3,153 pounds per acre, which is considerably less than the average product since the field was seeded. For the purpose of the experiment with nitrate of soda, eight equal plots have been laid off, each containing almost exactly one-third of an acre. During the past six years alternate plots in this series of eight have annually received a top-dressing of nitrate of soda. For the past three years, in order that this may be more uniformly spread, we have mixed the nitrate of soda for each plot with such a quantity of basic slag meal as to constitute an application of the latter at the rate of 400 pounds per acre. To equalize conditions on the alternate plots to which no nitrate is applied, the slag meal is applied to all of these at the same rate. The application of fertilizers to the several plots and the rates of yield per acre are shown in the following table: —

Nitrate of Soda for Rowen.

Plots.	Fertilizers used (Rates per Acre).	Yield (Pounds).	Increase per Acre (Pounds).
Plot 1, .	Slag meal, 400 pounds, ...	1,535	-
Plot 2, .	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	2,590	1,074
Plot 3, .	Slag meal, 400 pounds, ...	1,496	-
Plot 4, .	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	2,148	592
Plot 5, .	Slag meal, 400 pounds, ...	1,615	-
Plot 6, .	Slag meal, 400 pounds; nitrate of soda, 200 pounds,	2,648	1,027
Plot 7, .	Slag meal, 400 pounds, ...	1,627	-
Plot 8, .	Slag meal, 400 pounds; nitrate of soda, 250 pounds,	3,614	1,987

The nitrate of soda has in every instance given a considerable increase, — more than enough in every instance to cover the cost of the nitrate applied. As was pointed out last year, however, it is not believed that the large increase on plot 8 is altogether due to the nitrate used, for evidently the moisture conditions on this plot are rather better than on plot 7, with which it is compared. Of the six trials of nitrate of soda for rowen which have been completed, three have shown increases sufficiently large to make the application profitable, while in the other trials the application was made at a loss. As is natural, the result of an application of nitrate for rowen varies widely with the season. When such an application is followed by a sufficient and well-distributed rainfall, it gives a very profitable increase in the crop; but when the weather succeeding the application is dry, the nitrate is relatively non-effective. It is of course impossible to foresee the nature of the weather which will follow the use of nitrate. It would appear, however, that there is at least an equal chance that a moderate application will give a good margin of profit. Close observation of the field in which this experiment has been tried indicates that where, owing to succeeding relatively dry weather, the nitrate proves ineffective for the immediately succeeding crop of rowen, it will, nevertheless, on this fairly compact loam be retained by the soil in sufficient quantity to favorably influence the hay crop of the following season. We have as yet, however, no figures that can be presented which demonstrate this fact.

XI. — Variety Test, Potatoes.

During the past season we have carried out the second year's trial with twenty-five varieties of potatoes. The seed used in making these trials was all of our own production, and was kept under similar conditions throughout the winter. The soil in which the varieties were planted is a medium loam, which was used for corn in 1905. It received a liberal application of commercial fertilizers. The varieties under trial, the area planted to each, the actual yields for each and the rate per acre are shown in the following table: —

Variety.	Area planted (Acres).	Yield per Plot (Pounds).		Yield per Acre (Bushels).	
		Large.	Small.	Large.	Small.
Good as Gold,	.0104	52.00	16.00	83.33	25.64
Early Quebec,	.0104	98.00	5.50	157.05	8.81
Chenango White,	.0104	126.75	7.50	203.13	11.91
Reliance,	.0104	108.75	15.00	174.28	24.04
Early Canada,	.0104	112.50	8.50	180.16	13.62
Great Divide,	.0104	82.50	11.50	132.21	18.43
Beauty of Hebron,	.0104	100.00	16.25	160.26	26.04
Clark's Pride,	.0104	84.50	18.00	135.32	28.85
Extra Early White Rose,	.0104	105.50	7.25	169.07	11.62
Banner,	.0104	66.75	2.00	106.97	3.21
Early Rose,	.0104	106.00	14.50	169.87	23.24
Vermont Gold Coin,	.0104	99.25	11.25	159.06	18.03
Climax,	.0104	127.00	17.00	203.52	27.24
Short Seasons,	.0104	59.25	5.00	94.95	8.01
Gorthsap,	.0104	119.00	11.75	190.71	18.83
Dewey,	.0052	59.50	4.00	190.70	12.84
Hammond's Wonderful,	.0052	63.25	6.00	202.72	19.26
Salzer's Sunlight,	.0052	35.50	5.00	113.78	16.01
Keller,	.0052	36.50	1.50	116.99	4.81
Uncle Gideon's Quick Lunch,	.0052	20.75	10.50	66.51	33.65
Noroton Beauty,	.0052	30.75	5.00	98.56	16.01
Nebraska,	.0052	48.00	4.25	153.85	13.62
Simmon's Model,	.0052	63.50	5.50	201.92	17.62
Harris' Snowball,	.0026	18.00	2.00	115.38	12.82
Mills' New Rose Beauty,	.0026	17.25	3.25	110.58	20.83

It will be seen that most of the varieties gave a fairly satisfactory yield. Four only gave a yield of merchantable tubers in excess of 200 bushels; these, in the order of their rank, were: Climax, Chenango White, Hammond's Wonderful and Simmon's Model. Four varieties gave a yield at the rate of less than 100 bushels of merchantable tubers per acre; these, in the order of their inferiority, were: Uncle Gideon's Quick Lunch, Good as Gold, Short Seasons and Noroton Beauty.

The seed of all the varieties was treated with formalin, and the product was free from scab. They were twice sprayed with Bordeaux mixture. The varieties showing blight earliest were Good as Gold, Uncle Gideon's Quick Lunch and Noroton Beauty. All the vines of these varieties were dead on August 14, on which date Salzer's Sunlight, Climax and Clark's Pride were beginning to show blight. The six varieties named were the only ones apparently much affected. Among these varieties, all except Climax gave a small yield, those earliest blighted being among the very poorest.

XII. — Poultry Experiments.

The poultry work of the past year has been a repetition of the feeding experiments of the preceding year. These experiments had indicated: first, that, provided fat is abundant in the ration, high protein content is not essential; second, that, if the fat content of the ration is low, a large proportion of protein in the feeds used appears to be much more essential; and third, that a large proportion of fiber in the ration used is unfavorable to a good egg product. The fowls used in the experiment this year, as last, were pullets of our own raising; and in comparing different food combinations, carefully matched flocks have been kept, as in former years, each in a house by itself, all the houses being of precisely similar dimensions and construction.

1. The fowls in houses Nos. 1 and 2 have been fed on rations characterized by high content both of ash and fat and low fiber. As wheat is relatively deficient in fat, the ration in which it is largely used received an addition of

corn oil. This is mixed with the grains in the mash in such quantities that the total amount of fat in the two food combinations under comparison is substantially the same for each. This experiment, therefore, in a general way affords opportunity to test the relative value for egg production of a ration relatively high in protein (the one containing a large proportion of wheat) with one relatively low in protein (containing a large proportion of corn). The nutritive ratio of the ration used in house No. 1, which may be denominated "the wheat ration," is narrow, — 1 to 4.57. The ration used in house No. 2, which may be called "the corn ration," has a relatively wide nutritive ratio, — 1 to about 6.5. The animal food used in both these rations was beef scraps. The following results were obtained. For the first period, January 25 to April 28, inclusive, the wheat ration produced eggs at the average rate of .48 per hen day; the corn ration, at the rate of .54 per hen day. For the second period, April 28 to September 5, inclusive, the wheat ration produced eggs at the average rate of .37 per hen day; the corn ration, at the rate of .39. In other words, 100 hens, if laying at the same rates, would have produced during the winter period 48 eggs per day on the wheat ration and 54 eggs per day on the corn ration; during the summer period, 37 eggs per day on the wheat ration and 39 eggs per day on the corn ration. The average food cost per egg produced was: for the wheat ration .96 cents, and for the corn ration .73 cents, for the first period; while for the second period the food cost per egg on the wheat ration was 1.01 cents and on the corn ration .82 cents. The gross cost of the food on the wheat ration varied from about .37 cents to .42 cents per day for each fowl, while on the corn ration the cost varied from .31 cents to .36 cents per day. The number of eggs on the corn ration, as will have been noted, was considerably more than on the other. The cost per egg was smaller and the daily cost per fowl was smaller. The results of the past year are in exact accord with those obtained in similar experiments in earlier years. Our egg production with these pens of fowls must be regarded as fairly satisfactory, and it seems impossible to doubt that corn judiciously used in

combination with other foods has superior merits for egg production as compared with wheat.

2. The rations fed to the fowls in houses Nos. 3 and 4 were relatively high in ash and low in fiber. Milk albumen was the animal food used. This was selected on account of the low percentage of fat it contains, and the rations fed to the fowls in both of these houses were characterized by much lower fat contents than the rations fed to the fowls in houses Nos. 1 and 2. As in the experiment previously described, the fat content of the two rations used in houses Nos. 3 and 4 was equalized by the addition of corn oil to the one naturally lower in fat. Wheat was the leading grain in the ration fed to the fowls in house No. 3; corn the leading whole grain fed in the other house, No. 4. The results with the fowls in these houses, like the results obtained in houses Nos. 1 and 2, afford a basis for estimating the relative value of wheat and corn, but with a relatively low percentage of fat in both. The nutritive ratios used in this experiment were, for the ration containing wheat, 1 to 4.54; for the ration containing corn, 1 to 6.28. The egg product in this experiment was as follows: for the first period, January 25 to April 28, inclusive, for the wheat ration .49 and for the corn ration .47 eggs per hen day; for the summer period, April 28 to September 5, inclusive, for the wheat ration .35 and for the corn ration .46 eggs per hen day. In other words, 100 fowls, laying at similar rates, would have produced on the wheat ration 49 eggs per day during the winter period and 35 eggs per day during the summer period. On the corn ration, the same number of fowls would have laid 47 eggs per day during the winter period and 46 eggs per day during the summer period. It will be noticed that the result in the winter experiment is favorable to the ration containing the wheat. In the summer, on the other hand, it is favorable to the ration containing the corn. In the experiments reported last year the numbers of eggs both in the winter and in the summer period were greater on the wheat ration, although the cost per egg was less on the corn than on the wheat. In the experiments of the past year the gross cost of food per egg produced on the wheat ration has been

.96 cents both for the winter and summer periods. The gross cost of food per egg on the corn ration for the winter period was .86 cents and for the summer period .74 cents. This year, as last, therefore, the food cost per egg has been less on the corn than on the wheat. It is not easy to understand why the results as measured by the number of eggs produced in one instance should have been favorable to the wheat and in the other to the corn, but it may be that the difference in the average temperature of the two seasons in part accounts for it. It will be remembered that both rations in this experiment are low in fat. One of the products of protein metabolism in the animal body is fat, and fat, as is well understood, is the most effective heat producer. The higher protein content of the ration containing the more wheat may have proved serviceable, therefore, in enabling the fowls the better to maintain normal body temperatures during the cool weather. True, it is generally asserted that corn may be used more freely as a food for laying fowls in winter than in summer. It will be remembered, however, that in this experiment the fat content of the wheat ration was made equal to that of the corn ration by the addition of corn oil. It would seem, therefore, that, while the results in the two periods this year are not in exact agreement, they nevertheless in a general way support the conclusion which has previously been tentatively suggested, viz.: that, unless the fat content of the ration is relatively high, the more starchy foods are not sufficient to produce a satisfactory egg yield, and the product falls below that obtained from feeding a ration higher in protein.

3. The fowls in houses Nos. 5 and 6 received rations in both cases characterized by low protein, high ash and high fat content. The deficiency in fat in the grains selected was made up by the use of corn oil mixed with the meals used in the mash, as in the other experiments. The fowls in house No. 5 were fed grains, including oats and oat feed, characterized by a high proportion of fiber. Those in house No. 6 were fed grains among which rice, which is characterized by a very low percentage of fiber, was prominent. The object in this experiment was to get light regarding the influence

of fiber in the ration on egg production. The nutritive ratio in the two houses was kept substantially the same, about 1 to 6.5. The animal food used in these houses was beef scraps. The results were as follows: For the winter period, January 25 to April 28, inclusive, the egg production was: for the oat ration (high fiber), .32 per hen day; for the rice ration (low fiber), .46. For the summer period, April 28 to September 5, inclusive, the egg production was: for the oat ration (high fiber), .32; and for the rice ration (low fiber), .37 per hen day. In other words, 100 fowls, laying at the same rates, would have produced daily during the winter period, on the oat ration, 32 eggs; on the rice ration, 46 eggs; during the summer period, on the oat ration, 32 eggs; on the rice ration, 37 eggs. The food cost of the eggs was greater on the rice ration than on the oat ration. As has been pointed out in earlier reports, rice, on account of its high price, cannot as a rule be economically used as a food for laying fowls. It is used in this experiment because of its exceptionally low fiber content. The results of the past year are in exact accord with all earlier experiments testing this point. A large proportion of fiber in a ration for laying fowls seems to be highly unfavorable to a satisfactory egg product.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, EDWARD G. PROULX, E. T. LADD.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1906.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 40 have offices for the general distribution of their goods in Massachusetts, 11 in New York, 8 in Connecticut, 3 in Vermont, 2 in Ohio, 1 in Rhode Island, 1 in Maryland, 1 in Tennessee, 1 in Arkansas, 1 in Missouri, 1 in Canada, 1 in New Jersey and 1 in Pennsylvania.

Three hundred and fifty-four brands of fertilizers and chemicals have been licensed in Massachusetts during the year. Five hundred and thirty-three samples of fertilizers

have been collected up to December 10 in our general markets by an experienced assistant in this department.

Four hundred and ninety-seven samples of officially collected fertilizers have been analyzed at the present date (December 10), representing 323 distinct brands of fertilizers. Some of these analyses were published in our July bulletin No. 111; the others will be published in our January bulletin. The analyses of other officially collected samples of fertilizers, not included in these two publications, will be published in our March bulletin for 1907. Twenty-eight more brands of fertilizers were licensed in Massachusetts during the year than in 1905, and 10 more have been analyzed than during the past year.

The following table shows the general character of the fertilizers analyzed during 1906, as compared with the previous year: —

	1905.	1906.
(*a*) Where three essential elements of plant food were guaranteed (complete fertilizers): —		
Number with three elements equal to or above the highest guarantee,	11	9
Number with two elements above the highest guarantee,	15	22
Number with one element above the highest guarantee,	59	71
Number with three elements between the highest and lowest guarantee,	100	106
Number with two elements between the highest and lowest guarantee,	74	71
Number with one element between the highest and lowest guarantee,	24	41
Number with three elements below the lowest guarantee,	1	0
Number with two elements below the lowest guarantee,	14	14
Number with one element below the lowest guarantee,	48	45
(*b*) Where two essential elements of plant food were guaranteed (bones, tankage, fish and ashes): —		
Number with two elements above the highest guarantee,	5	3
Number with one element above the highest guarantee,	22	20
Number with two elements between the lowest and highest guarantee,	12	7
Number with one element between the lowest and highest guarantee,	14	18
Number with two elements below the lowest guarantee,	2	4
Number with one element below the lowest guarantee,	13	8
(*c*) Where one essential element of plant food was guaranteed (chemicals): —		
Number above the highest guarantee,	11	13
Number between the lowest and highest guarantee,	13	18
Number below the lowest guarantee,	10	13

The quality of the officially collected fertilizers for 1906, as shown by the above table, shows a gain over the previous year.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1905 and 1906 (Cents per Pound).

	1905.	1906.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	17.00	16.50
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	18.50	18.50
Organic nitrogen in fine bone and tankage,	18.00	18.00
Organic nitrogen in coarse bone and tankage,	13.00	13.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and neutral citrate of ammonia) in mixed fertilizers,	2.00	2.00
Potash as sulphate (free from chlorides),	5.00	5.00
Potash as muriate (chloride),	4.25	4.25
Potash as carbonate,	8.00	8.00

A comparison of the market cost of the various forms in which the three essential elements of plant food are found shows the nitrogen in the form of nitrates to be a half-cent lower in cost than for the previous year; the cost of the other forms of nitrogen, as well as the various sources of potash and phosphoric acid, remains the same as for 1905.

The above schedule of trade values was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of February, 1906, and is based upon the condition of the fertilizer market in centers of distribution in New England, New York and New Jersey during the six months preceding March, 1906, and refers to the current market prices, in ton lots, of the leading standard raw materials which furnish nitrogen, phosphoric acid and potash, and which enter largely into the manufacture of our commercial fertilizers.

Table A, on a following page, gives the average composition of licensed commercial fertilizers for 1906.

Table B gives a compilation of analyses of the so-called special crop fertilizers, and shows the wide variation in the

chemical composition of this class of goods, the variation in some cases amounting to 10 or 12 per cent. in some one element of plant food which is recommended and used by different manufacturers in compounding a fertilizer for some special crop. This is proof positive that the purchaser of commercial fertilizers must have some more reliable method of selecting his fertilizers than by using the manufacturers' trade names, which, being so contradictory, confuse rather than aid the intelligent buyer. No infallible rule can be laid down in selecting a fertilizer, as so much depends upon the method of crop rotation, the kind of farming in practice, and general soil conditions and requirements. The user of commercial fertilizers will, however, make no mistake in selecting a *high-grade* fertilizer; but whether to select a fertilizer containing a high percentage of some one element of plant food, and how to be guided in this matter, must rest with the individual consumer. The plant food requirements of different soils, as well as different crops, vary widely; and the farmer must discover what particular fertilizing element or elements will most benefit his soil, and select his fertilizer accordingly.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1906 (Per Cent.).*

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
General fertilizer,	10.18	3.14	2.71	4.18	3.42	2.91	10.51	8.91	7.60	7.30	5.30	5.05
Ground bone,	6.80	2.98	2.56	-	8.54	16.33	24.87	22.38	8.54	7.81	-	-
Tankage,	9.72	5.39	5.19	-	6.15	10.19	16.34	14.73	6.15	-	-	-
Dry ground fish,	8.26	8.14	8.24	-	3.86	3.95	7.82	6.80	3.86	-	-	-
Basic slag,	-	-	-	-	6.72	12.27	18.99	18.00	6.72	-	-	-
Dissolved bone black,	12.11	-	-	10.77	4.92	1.21	17.01	16.00	15.70	15.00	-	-
Dissolved bone,	6.61	2.46	1.65	5.60	8.42	3.08	17.10	14.00	14.02	12.00	-	-
Acid phosphate,	12.62	-	-	10.85	3.97	1.52	16.34	11.66	14.82	13.00	-	-
Wood ashes,	13.96	-	-	-	-	-	1.33	1.12	-	-	5.77	4.80
Nitrate of soda,	1.76	15.57	15.42	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.76	20.78	19.00	-	-	-	-	-	-	-	-	-
Dried blood,	7.55	9.30	9.50	-	-	-	-	-	-	-	-	-
Cotton-seed meal,	6.91	6.69	6.46	-	-	-	-	-	-	-	-	-
Cleveland flax meal,	9.52	6.00	5.76	-	-	-	-	-	-	-	-	-
Chincha Peruvian guano,	10.65	7.33	7.06	2.49	4.80	2.72	10.01	8.50	7.29	6.50	1.88	2.00
Lobos Peruvian guano,	10.40	3.41	3.15	2.78	5.75	9.04	17.57	19.00	8.53	10.00	3.90	3.30
Carbonate of potash,	None.	-	-	-	-	-	-	-	-	-	67.10	67.00
Sulfate of potash,	.84	-	-	-	-	-	-	-	-	-	49.34	48.25
Muriate of potash,	1.36	-	-	-	-	-	-	-	-	-	50.42	50.00
Sulfate of potash-magnesia,	3.95	-	-	-	-	-	-	-	-	-	25.92	26.00
Kainit,	2.07	-	-	-	-	-	-	-	-	-	12.84	12.00

TABLE B. — *Compilation of Analysis of Officially Collected Fertilizers for 1906, Special Crop Brands (Per Cent.).*

NAME OF FERTILIZER.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	10.77	4.16	1.61	2.61	16.64	9.22	11.55	9.66	5.12	8.39	10.94	1.80	4.00
Fruit and vine,	9.77	2.78	2.50	2.64	13.86	7.24	10.55	10.84	3.78	7.31	11.42	3.32	7.37
Grass fertilizer,	7.89	5.69	3.10	4.27	14.32	4.84	9.17	10.98	2.78	6.38	8.30	2.06	5.28
Market garden fertilizer,	9.77	4.68	2.03	3.19	14.00	7.16	10.65	10.08	5.76	7.63	12.08	2.06	6.67
Onion fertilizer,	10.72	4.31	3.62	3.88	12.10	7.88	10.18	9.98	6.50	7.80	7.98	6.28	6.95
Potato fertilizer,	10.80	5.62	1.32	2.81	15.46	6.70	10.61	9.72	4.16	7.68	10.14	3.10	6.09
Root crop fertilizer,	10.56	3.66	2.75	3.28	11.90	9.86	10.89	8.90	7.26	8.22	7.66	6.50	7.23
Tobacco fertilizer,	8.56	8.56	1.09	4.42	15.08	4.24	8.06	9.14	2.40	5.85	15.88	2.62	6.40

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1906, to May 1, 1907), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- High-grade Fertilizer with Ten Per Cent. Potash.
- Grass and Lawn Top-dressing.
- Tobacco Starter and Grower.
- Fine-ground Bone.
- Dissolved Bone Black.
- Muriate of Potash.
- Double Manure Salt.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dry Ground Fish.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- Dried Blood.
- Fine-ground Tankage.
- Ground South Carolina Phosphate.
- High-grade Tobacco Manure.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's Complete for Potatoes and Vegetables.
- Bradley's Complete for Corn and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Top-dressing Grass and Grain.
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Columbia Fish and Potash.
- Bradley's Abattoir Bone Dust.
- Bradley's Seeding-down Manure.
- Church's Fish and Potash.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A. A. Ammoniated Superphosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer G. G.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass. — *Con.*
- Clark's Cove Great Planet Manure.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Darling's Blood, Bone and Potash.
- Darling's Complete Ten Per Cent. Manure.
- Darling's Potato Manure.
- Darling's Farm Favorite.
- Darling's Potato and Root Crop Manure.
- Darling's General Fertilizer.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Great Eastern Northern Corn Special.
- Great Eastern Vegetable Vine and Tobacco.
- Great Eastern Garden Special.
- Great Eastern General.
- Great Eastern Grass and Oats Fertilizer.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Potato Special.
- Soluble Pacific Guano.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Packers' Union Gardeners' Complete Manure.
- Packers' Union Animal Corn Fertilizer.
- Packers' Union Potato Manure.
- Packers' Union Universal Fertilizer.
- Packers' Union Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Market-garden Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Corn Manure.
- Quinnipiac Climax Phosphate.
- Quinnipiac Onion Manure.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Practical Potato Special.
- Read's Farmer's Friend.
- Read's Standard.
- Read's High-grade Farmer's Friend.
- Read's Vegetable and Vine.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Complete Manure.
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Wheeler's Corn Fertilizer.
- Wheeler's Potato Manure.
- Wheeler's Havana Tobacco Grower.
- Wheeler's Bermuda Onion Grower.
- Wheeler's Grass and Oats Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Abbott's Tobacco Fertilizer.
- Abbott's Onion Fertilizer.
- Abbott's Animal Fertilizer.
- Abbott's Eagle Brand Fertilizer.

The American Cotton Oil Co., New York City: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

The Armour Fertilizer Works, Baltimore, Md.: —
- Fruit and Root Fertilizer.
- Blood, Bone and Potash.
- High-grade Potato.
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.
- Complete Potato.
- Corn King.
- Market Garden.
- Grain Grower.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Reliance Brand.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Potato and Vegetable Phosphate.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Grass Fertilizer.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash ("D" Brand).
- Bowker's Corn Phosphate.
- Bowker's Bone, Blood and Potash.
- Bowker's Early Potato Manure.
- Bristol Fish and Potash.
- Bowker's Fine-ground Fish.
- Bowker's Tobacco Ash Elements.
- Bowker's Wood Ashes.
- Bowker's Ground Bone.
- Bowker's Superphosphate.
- Bowker's Sulfate of Ammonia.
- Bowker's Nitrate of Soda.
- Bowker's Dissolved Bone Black.
- Bowker's Kainit.
- Bowker's Muriate of Potash.
- Bowker's Sulfate of Potash.
- Dried Blood.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.
- Bowker's Market-garden Fertilizer.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Bowker's Double Manure Salt.
- Bowker's Tankage.
- Bowker's Clover Brand Bone and Wood Ash Fertilizer.
- Bowker's Flour of Bone.
- Bowker's Market Bone.
- Bowker's Ground Phosphate Rock.
- Bowker's Ammoniated Dissolved Bone.
- Bowker's Square Brand Bone and Potash.
- Bowker's Potash or Staple Phosphate.
- Bowker's Special Fertilizer for Seeding Down.

F. W. Brode & Co., Memphis, Tenn.: —
- Owl Brand Cotton-seed Meal.

T. H. Bunch Co., Little Rock, Ark.: —
- Cotton-seed Meal.

The Buffalo Fertilizer Co., Buffalo, N. Y.: —
- Fish Guano.
- Farmer's Choice.
- York State Special.
- Vegetable and Potato.
- Garden Truck.
- High-grade Manure.

Charles M. Cox Co., Boston, Mass.: —
- Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass.: —
- Farquhar's Lawn and Garden Dressing.
- Farquhar's Vegetable and Potato Fertilizer.

The Coe-Mortimer Co., New York, N. Y.: —
- New Englander Corn and Potato Fertilizer.
- Columbian Corn and Potato Fertilizer.
- Basic Slag.
- Excelsior Potato Fertilizer.
- Gold Brand Excelsior Guano.
- X X X Ammoniated Bone Phosphate.
- Nitrate of Soda.
- Celebrated Special Potato.
- High-grade Ammoniated Bone Superphosphate.
- Chincha Peruvian Guano.
- Lobos Peruvian Guano.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Plant Food.

R. & J. Farquhar & Co., Boston, Mass.: —
- Canada Unleached Hard-wood Ashes.
- Clay's London Fertilizer.

Fyfe, Fay & Plummer, Clinton, Mass.: —
- Hard-wood Canada Ashes.

C. B. Hastings, Ashmont, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Bone Meal.

The Home Soap Co., Worcester, Mass.: —
Ground Bone.

Hunter Brothers Milling Co., St. Louis, Mo.: —
Cotton-seed Meal.

John Joynt, Lucknow, Ontario, Can.: —
Unleached Hard-wood Ashes.

A. Klipstein & Co., New York, N. Y.: —
Carbonate of Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's High-grade Special.
Lister's Success.
Lister's Special Corn.
Lister's Special Potato.
Lister's Potato Manure.
Lister's Oneida Special.
Lister's Bone and Potash.

Stephen Major, South Somerset, Mass.: —
Major's Bone Phosphate No. 1.

Edward MacMulkin, Boston, Mass.: —
Ideal Plant Food.

Swift's Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Potato Phosphate.
Swift's Lowell Dissolved Bone and Potash.
Swift's Lowell Animal Brand.
Swift's Lowell Market-garden Manure.
Swift's Lowell Potato Manure.
Swift's Lowell Empress Brand.
Swift's Lowell Superior Fertilizer.
Swift's Lowell Special Grass Mixture.
Swift's Lowell Lawn Dressing.
Swift's Lowell Perfect Tobacco Grower.
Swift's Lowell Ground Bone.
Acid Phosphate.
Nitrate of Soda.
Muriate of Potash.
Tankage.
Dried Blood.
High-grade Sulfate of Potash.
Dissolved Bone Black.
Swift's Lowell Special Vegetable Fertilizer.

George E. Marsh & Co., Lynn, Mass.: —
Bone Meal.

Mapes Formula & Peruvian Guano Co., New York, N. Y.: —
Mapes' Grass and Grain Spring Top-dressing.
Mapes' Complete Manure for General Use.
Mapes' Fruit and Vine Manure.
Mapes' Cereal Brand.
Mapes' Lawn Top-dressing.
Mapes' Cauliflower and Cabbage Manure.
Mapes' Potato Manure.
Mapes' Tobacco Starter Improved.
Mapes' Tobacco Manure (Wrapper Brand).
Mapes' Economical Potato Manure.
Mapes' Average Soil Complete Manure.
Mapes' Vegetable Manure or Complete Manure for Light Soils.
Mapes' Corn Manure.
Mapes' Complete Manure ("A" Brand).
Mapes' Complete Manure Ten Per Cent. Potash.
Mapes' Top-dressing Improved, Half Strength.
Mapes' Tobacco Ash Constituents.

George L. Monroe & Sons, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

D. M. Moulton, Monson, Mass.: —
Ground Bone.

W. H. Nash, Boston, Mass.: —
Lime-Kiln Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
Chittenden's Ammoniated Bone.
Chittenden's Universal.
Chittenden's Potato Phosphate.
Chittenden's Complete.
Chittenden's Fish and Potash.
Chittenden's Tobacco Starter.
Chittenden's Tobacco Grower.
Chittenden's Market Garden.
Chittenden's Tobacco Special.
Chittenden's Complete Tobacco.
Chittenden's High-grade Special Tobacco.

New England Fertilizer Co., Boston, Mass.: —
New England Corn Phosphate.
New England Potato Fertilizer.
New England Superphosphate.
New England High-grade Potato Fertilizer.

Olds & Whipple, Hartford, Conn.: —
Complete Tobacco Fertilizer.
Home Mixture for Onions.
Vegetable Potash.
Corn and Potato Fertilizer.
Cotton-seed Meal.

R. T. Prentiss, Holyoke, Mass.: —
Complete Fertilizers.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Plymouth Rock Brand.
Strawberry Special.
Special Potato.
A. A. Brand.
P. & P. Potato.
Lawn Dressing.
P. & P. Grain Grower.
Star Brand.
Pure Ground Bone.
Nitrate of Soda.
Aroostook Special.

Rogers & Hubbard Co., Middletown, Conn.: —
Hubbard's Complete Phosphate.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Market-garden Phosphate.
Hubbard's Oats and Top-dressing.
Hubbard's Potato Phosphate.
Hubbard's Soluble Corn and General Crops.
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Raw Knuckle Bone Flour.
Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.: —
All-round Fertilizer.
Complete Potato and Vegetable Fertilizer.
High-grade Complete Corn and Onion.
Fish and Potash.
High-grade Tobacco and Potato.
High-grade Oats and Top-dressing.
High-grade Grass and Grain.
High-grade Soluble Tobacco.
Pure Knuckle Bone.

Ross Brothers, Worcester, Mass.: —
Lawn and Garden Fertilizer.

N. Roy & Son, South Attleborough, Mass.: —
Potato Fertilizer.
Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
Essex Dry Ground Fish.
Essex Complete for Corn, Grain and Grass.
Essex Complete for Potatoes, Roots and Vegetables.
Essex Market-garden and Potato Manure.
Essex Corn Fertilizer.
Essex A. 1. Superphosphate.
Essex X X X Fish and Potash.
Essex Odorless Lawn Dressing.
Essex Tobacco Starter.
Essex Special Tobacco Manure.
Essex Rhode Island Special for Potatoes.
Essex Grass and Top-dressing.
Essex Nitrate of Soda.

The Salisbury Cutlery Handle Co., Salisbury, Conn.: —
Ground Bone.

Sanderson's Fertilizer & Chemical Co., New Haven, Conn.: —
Sanderson's Formula "A."
Sanderson's Formula "B."
Sanderson's Top-dressing Grass and Grain.
Sanderson's Potato Manure.
Sanderson's Atlantic Coast Bone, Fish and Potash.
Sanderson's Fine-ground Fish.
Nitrate of Soda.
High-grade Sulfate of Potash.
Muriate of Potash.
Plain Superphosphate.
Walker's Complete Phosphate.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
Swift Sure Superphosphate.
Swift Sure Bone Meal.

The Smith Agricultural Chemical Co. (Abbott and Martin Rendering Co., branch), Columbus, O.: —
Harvest King.
Tobacco and Potato Special.
Martin's Truck Fertilizer.

The Smith Agricultural Chemical Co. (Hardy Packing Co., branch), Columbus, O.: —
Tankage, Bone and Potash.
Tobacco and Potato Special.

Sterling Chemical Co., Cambridgeport, Mass.: —
Sterlingworth Concentrated Plant Food.

Thomas L. Stetson, Randolph, Mass.: —
Stetson's Ground Bone.

A. L. Warren, Northborough, Mass.: —
Warren's Ground Bone.

Whitman & Pratt Rendering Co., Lowell, Mass.: —
Vegetable Grower.
All Crops Fertilizer.
Corn Success.
Potato Plowman.
Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Vegetable Manure.
Potato Fertilizer.
Complete Bone Superphosphate.
Fish and Potash.
High-grade Tobacco Special.
Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
Winter's Ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.

1. Analyses of Materials forwarded for Examination.

During the year 343 samples of miscellaneous substances have been received from farmers within our State. These samples have been analyzed as expeditiously as possible, the samples being taken up, as a rule, in the order of their arrival at this office; although precedence is sometimes given to farmers' clubs, grange organizations and private parties, who depend upon the results of our analysis as a basis for settlement for their fertilizers. We have most time at our disposal for this class of work from the middle of December until the first of April, as during this time we are not engaged in the annual inspection of commercial fertilizers. Whenever practical, it would be well for those who desire a speedy return of results of analyses to take advantage of this fact, and send samples for analysis before the beginning of our inspection season.

During the year we have been in co-operation with the Association of Official Agricultural Chemists, studying new methods of analyses of soils, fertilizers and insecticides. This is a very important part of the practical chemists' work, and time should be taken every year for this co-operative investigation.

The year has seen some new developments along the line of producing valuable agricultural compounds for fertilizing purposes. These developments have naturally inclined

towards producing new compounds of our most expensive element of plant food, nitrogen. Statistics show that, at the present rate of consumption, it is only a matter of a few years before the supply of nitrate of soda from our present source will become exhausted. This will become a very serious matter, unless new deposits of nitrate are discovered, or science shows us an economical method of utilizing the inexhaustible supply of atmospheric nitrogen. Attempts have been made to manufacture nitric acid by an electrical method which utilizes the nitrogen of the air, and which has proven more or less successful. Attempts have also been made to combine the atmospheric nitrogen with lime to form cyanimid compounds. This method has also been successful, but whether these cyanimid compounds will prove practical fertilizers or not we are at present unable to say. It has long been known that cyanogen compounds are poisonous to plant growth; but they are easily decomposed, and it is possible that it may be found safe to use them by applying them to the soil some time previous to the planting of the crop.

During the year we have heard much about the use of ground feldspar and granitic rocks as a source of potash. In the early history of the use of artificial fertilizers, potash in the form of silicates was recommended. They were, however, found unsuitable as a source of potash, as they were not easily decomposed, and the more soluble forms of potash soon took their place. It is a well-known fact that many soils of granitic origin are benefited by an application of soluble potash compounds. In view of the above facts, we would caution the user of commercial fertilizers against purchasing ground feldspathic rocks as a source of potash. Through a process of electrolysis and endosmosis, investigators have succeeded in recovering 80 per cent. of the potash in feldspathic rocks. In this age of cheapening electrical power it may not be impossible that this process may be successfully employed to economically produce potash for our future needs in the fertilization of agricultural soils for farm crops.

Following is a partial list of materials forwarded by farmers during the year: —

Soils,	55	Leather dust,	1
Complete fertilizers,	45	Tobacco stems,	1
Wood ashes,	41	Kainit,	1
Cotton-seed meal,	28	Pigeon manure,	1
Nitrate of soda,	13	Clay,	1
Peruvian guano,	11	Bone soup,	1
Carbonate of potash,	7	Peat,	1
Sulfate of potash,	8	Wool washings,	1
Ground bones,	6	Arsenate of soda,	1
Dry ground fish,	6	London purple,	1
Fine-ground tankage,	6	Saltpeter waste,	1
Lime ashes,	6	Bone waste,	1
Paris green,	6	Horn waste,	1
Dried blood,	4	Coal ashes,	1
Dissolved bone black,	4	Sludge from filter beds,	1
Muriate of potash,	4	Hoof meal,	1
Cotton waste,	4	South Carolina rock phosphate,	1
Sheep manure,	4	Manure,	1
Lime,	3	Sulfate of ammonia,	1
Dissolved bone,	3	Steamed bone,	1
Sulfate of potash-magnesia,	3	Manure and lime,	1
Nitrate of potash,	3	Bone scrap,	1
Arsenate of lead,	3	Burned bone,	1
Acid phosphate,	4	Carbonate of potash-magnesia,	1
Phosphatic slag,	3	Calcium cyanimid,	1
Oyster-shell lime,	2	Washings from paper mill,	1
Linseed meal,	2	Soft coal soot,	1
Muck,	2	Castor pomace,	1
Granite,	2	Nitrogenous chalk,	1
Talc,	2	Peat and manure,	1
Cotton-hull ashes,	2	Wool waste,	1
Leather refuse,	2	River mud,	1
Glue refuse,	1	Woodland leaf mold,	1
Cave deposit,	1	Miscellaneous,	12
Carbonate of lime,	1		

2. Notes on Wood Ashes and Lime Ashes.

(a) *Wood Ashes.*

Forty-one samples of wood ashes have been forwarded for analysis by farmers during the past year. The majority of these ashes are used by the farmers in the Connecticut valley. The following table shows their chemical composition as compared with 1905: —

Analysis of Wood Ashes.

	Number of Samples.	
	1905.	1906.
Moisture from 1 to 10 per cent.,	15	8
Moisture from 10 to 20 per cent.,	20	19
Moisture from 20 to 30 per cent.,	7	10
Moisture above 30 per cent.,	1	0
Potassium oxide above 7 per cent.,	4	3
Potassium oxide from 6 to 7 per cent.,	4	7
Potassium oxide from 5 to 6 per cent.,	12	6
Potassium oxide from 4 to 5 per cent.,	13	9
Potassium oxide from 3 to 4 per cent.,	7	9
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	7	1
Phosphoric acid from 1 to 2 per cent.,	32	31
Phosphoric acid below 1 per cent.,	4	6
Average per cent. of calcium oxide,	32.30	28.17
Insoluble matter below 10 per cent.,	9	3
Insoluble matter from 10 to 15 per cent.,	14	16
Insoluble matter above 15 per cent.,	20	18

Table showing Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes, 1905 and 1906.

	Maximum.		Minimum.		Average.	
	1905.	1906.	1905.	1906.	1905.	1906.
Moisture at 100° C.,	32.65	26.17	.02	.65	13.45	14.78
Potassium oxide,	8.68	7.54	2.32	2.75	5.09	5.02
Phosphoric acid,	4.74	2.90	.38	.44	1.69	1.28
Calcium oxide,	49.24	35.60	21.17	19.28	32.30	28.17
Insoluble matter,	33.32	30.25	4.15	4.04	15.49	16.02

A comparison of the figures in the above tables shows that the ashes analyzed during the season contained, on the average, less potash, phosphoric acid and lime and more water and sand than during the previous year. This emphasizes the importance of buying this class of material on a statement of guarantee of potash, phosphoric acid and lime; also of patronizing those importers who have complied with our State laws, and have secured licenses for the sale of wood ashes in Massachusetts. A list of these importers will be found on a previous page of this report.

(*b*) *Lime Ashes.*

Table showing Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes, 1905 and 1906.

	Maximum.		Minimum.		Average.	
	1905.	1906.	1905.	1906.	1905.	1906.
Moisture at 100° C.,	19.35	21.65	.05	none.	11.18	5.99
Potassium oxide,	4.80	3.72	1.02	1.44	2.46	2.54
Phosphoric acid,	1.58	1.16	.18	.34	.97	.71
Calcium oxide,	63.44	49.74	37.56	29.33	49.34	40.39
Insoluble matter,	28.93	34.93	3.21	4.04	8.99	9.51

The average composition of lime ashes is about the same as for the previous year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemists: E. B. HOLLAND, P. H. SMITH, A. C. WHITTIER,[1] L. S. WALKER.[2]

Inspector of Feeds and Babcock Machines: F. G. HELYAR,[3] W. K. HEPBURN.

Dairy Tester: S. R. PARKER,[4] H. A. PARSONS.

In Charge of Feeding Experiments: R. F. GASKILL.

Clerk and Stenographer: MABEL C. SMITH.

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[1] Resigned July 1.
[2] Since July 1.
[3] Resigned October 1.
[4] Resigned June 1.

Part I.—Outline of the Year's Work.

J. B. LINDSEY.

Correspondence.

A considerable correspondence is carried on yearly with farmers, grain dealers and other station workers. Numerous questions are asked concerning feeds and methods of feeding. The execution of the dairy and feed law involves the exchange of many letters. Letters of all kinds, sent from Dec. 15, 1905, through Dec. 15, 1906, approximated 3,200.

Summary of Laboratory Work.

From Dec. 15, 1905, to Dec. 15, 1906, there have been received and examined 124 samples of water, 310 of milk, 1,799 of cream, 152 of feed stuffs and 2 miscellaneous. In connection with experiments made by this and other divisions of the station, there have been examined, in whole or in part, 336 samples of milk and cream and 187 of cattle feeds. There have also been collected and examined 703 samples of cattle feeds, in accordance with the requirements of the feed law. The total for the year has been 3,613, as compared with 4,042 in 1905 and 4,261 during 1904. Work with condensed milk, molasses, maple sugar, ash and nitrogen, not included in the above summary, has been carried on for the Association of Official Agricultural Chemists. Twenty-three candidates have been examined and given certificates to operate Babcock machines, and 2,457 pieces of Babcock glassware have been tested for accuracy of graduation.

Water Analysis.

The station continues to make sanitary analyses of drinking waters, at a charge of $3 each. Special jars are furnished, together with full instructions for collecting and

forwarding the samples. An analysis of water sent in shippers' jars will not be made, neither will bacteriological nor mineral analyses be undertaken.

The character of the samples received has been much the same as that of those examined in previous years. They were mostly from wells or springs, which frequently were located in too close proximity to houses, barns and outbuildings, and received the drainage. Samples are often found contaminated with lead; the station can only repeat its warning that all lead pipe be discarded, and replaced with iron coated with asphaltum, or with galvanized-iron pipe.

Dairy Products and Cattle Feeds.

Farmers and dairymen continue to send samples of cream and skim milk to be tested for butter fat, and samples of whole milk to be tested for both solids and fat. More milk is being sold for market purposes than formerly, and less made into butter. The inspection of the quality of milk is more general and rigid from year to year. Dairymen wish to ascertain the composition of milk produced by individual cows and by their herds, and likewise to confirm analyses reported to them by the city milk inspectors and by contractors. This work is performed gratis, and the results reported promptly, together with such remarks and suggestions as special cases call for. One creamery sends all of the cream samples to be tested regularly, and others send occasional lots when not in condition to perform the work. A charge sufficient to cover the cost is made in such cases.

Samples of feeds (mostly concentrates) are received from farmers, as well as from local grain dealers and jobbers. The station willingly examines such material without charge, when it seems that the conditions warrant it, and promptly reports its findings with suggestions when necessary. It must be understood, however, that it cannot become the free chemists of jobbers and manufacturers who wish to have analyses made purely for commercial purposes.

Special Chemical Work.

This division has devoted some time to a study of methods used in chemical analysis, in co-operation with the Association of Official Agricultural Chemists. The work undertaken was as follows: —

1. A comparison of the Kjeldahl, Kjeldahl-Gunning and modified Gunning methods, for the determination of total organic nitrogen.

2. The determination of available organic nitrogen by the neutral permanganate and by the alkaline permanganate methods.

3. A study of the Babcock asbestos, dish and sand, and Gottlieb methods, Babcock centrifugal and Leach and Farrington modifications of the same, for the determination of fat in sweetened and unsweetened condensed milk.

4. Observations in the determination of lactose and sucrose in sweetened and unsweetened condensed milk, by aid of Fehling's solution, the copper being titrated with thiosulfate.

5. Determinations of moisture, ash, protein, dextrose and sucrose in massecuit, sugar and molasses. Considerable time was spent in a special study of different methods for the accurate determination of moisture in molasses, which has not been reported; it will be published when sufficient data have been secured to warrant the making of positive deductions.

6. Determinations of total, soluble and insoluble ash in pure and adulterated maple sugar, as well as the alkalinity of the soluble and insoluble ash.

The results of the above work were presented to the association, and became a part of their yearly report. It was carried out by Messrs. Holland and Smith, to whom due credit should be given.

In addition to the above, work is now in progress in determining the water and starch in 36 samples of potatoes.

Execution of the Feed Law (Acts of 1903, Chapter 122).

The methods employed in carrying out the provisions of this act have been essentially the same as in former years. The State has been thoroughly canvassed twice, the first time in January, February and March, and the second time in August, September and October. The inspector also spent the larger part of May in the most important grain-consuming portions of the State, and in addition made several short trips. There have been collected and examined during the year 703 samples of cattle and poultry feeds. Bulletin No. 108, containing the analyses of 365 samples collected during the autumn of 1905, was issued in January, 1906. Another bulletin is now being prepared for publication, and will be issued in December or early January. In addition to the regular yearly bulletin, the station sends out many letters to dealers and manufacturers concerning the values of feeds and explanatory of the feed law.

The only really adulterated feeds now on the market consist of mixtures of wheat bran and corn cobs. Such goods are usually properly guaranteed, but it is believed that unscrupulous dealers are inclined to remove the tags before selling, and dispose of them for genuine mixed wheat feeds.

Cotton-seed meal offered in local markets has shown a gradual decline in quality since 1902, while the price per ton has increased steadily since 1898. Gluten meal and germ oil meal are no longer offered. Distillers' dried grains are easily obtainable at reasonable prices. Brewers' dried grains of excellent quality have been placed in Massachusetts markets during the past year.

A number of proprietary grain mixtures or ready grain rations for dairy stock are now on sale, several of which are quite satisfactory; the price asked, however, is in excess of equally desirable mixtures which can be prepared by the dairymen from standard concentrates to be had of all local grain dealers.

Mixtures of corn, together with different amounts of oat residues, often designated stock foods, are widely distrib-

uted, and, judging from the number of brands, must find a ready sale. The corn is frequently of poor quality, being imperfectly developed, musty and sour. The price asked is usually in excess of their real value.

The number of brands of poultry foods, such as meat scraps, meat and bone meal, poultry meals and mashes, chick and scratching grains, is increasing from year to year. Poultrymen can prepare equally as desirable mashes or scratching mixtures for 25 cents less per hundred pounds. Full details concerning the great variety of cattle and poultry feeds now for sale in the markets of the State may be found by consulting the special feed bulletins.

Execution of the Dairy Law (Acts of 1901, Chapter 202).

The station has done its best to carry out the provisions of this law, which makes it obligatory for all creameries and milk depots in the State employing the Babcock test, or any other test for determining the value of milk or cream, to have all glassware used in making such determinations tested for accuracy of graduation. The law further requires that all parties intending to operate such machines be examined for competency by the proper station official. The station is also required once each year to send a competent party to each creamery and milk depot within the State where Babcock machines are in use, and pronounce upon their fitness for the work.

(*a*) *Inspection of Glassware.* — Each piece of glassware found to be correctly graduated has the letters "Mass Ex St" etched on. There were examined 2,457 pieces, of which 763, or 31.05 per cent., were condemned. This record shows gross carelessness on the part of some manufacturers.

(*b*) *Examination of Candidates.* — Twenty-three candidates have been examined during 1906. Some were well prepared, while others were refused a certificate on first trial and were obliged to take a second examination. The value of the law requiring the inspection of glassware and the examination of operators is made especially clear by the above records.

(*c*) *Inspection of Babcock Machines.* — The inspection of machines the present year has been in charge of Mr. William K. Hepburn, who makes the following report: —

The annual inspection of Babcock machines was made in November and December of 1906. Fifty-one places were either visited or heard from, but of these only 33 came under the law requiring inspection. Those not coming within the law have no machine in many cases, and as far as can be learned neither sell nor buy on the test basis.

Of the entire number, 28 are creameries and 23 milk depots. Nineteen of the creameries are co-operative, and 9 are either proprietary or managed by stock companies. The milk depots are in nearly every case proprietary. Thirty-three machines were inspected and found in good condition, only 1 needing minor repairs. Nearly all the machines in use have cast-iron frames, and of these 16 are Facile, 8 Agos and 3 Wizard. In addition to the above, there were in use 3 steam machines having galvanized frames and 3 electrical machines. In a few cases the machines still overheat the tests, but allowance is made for this by letting them run a little longer with the cover lifted.

Most of the glassware was found in good condition, although a few still use very dirty bottles, — a practice which cannot be too strongly condemned. Beside the regular inspection, four city milk inspectors were visited; they did not care to have their machines tested.

The following parties claim they do not pay on the Babcock basis, but by the space, can, 100 pounds or quart: —

Amherst Co-operative Creamery.
Fort River Creamery of Amherst.
Leominster Creamery.
Echo Farm Dairy of South Framingham.
Fitchburg Creamery.
Boston Dairy Company of Gardner.
James Lawrence Creamery of Groton.
Este Creamery of Marlborough.
F. D. Shove Creamery of West Stockbridge.
Wachusett Creamery of Worcester.
Worcester Dairy Company.

The following is a list of the most important creameries and milk depots now in operation: —

1. Creameries.

Location.	Name.	President or Manager.
Amherst,	Amherst Co-operative,	F. J. Humphrey, agent.
Amherst,	Fort River,	E. A. King.
Ashfield,	Ashfield Co-operative,	G. G. Henry, manager.
Belchertown,	Belchertown Co-operative,	M. G. Ward, president.
Cheshire (P. O. Adams),	Greylock Co-operative,	C. J. Fales, president.
Cheshire,	Highland,	C. W. Prince.
Cheshire,	West Shore,	S. W. Curtis.
Cummington,	Cummington Co-operative,	W. E. Partridge, manager.
Easthampton,	Hampton Co-operative,	W. A. Wright, superintendent.
Egremont (P. O. North Egremont).	Egremont Co-operative,	H. O. Harrington, manager.
Heath,	Cold Spring,	I. W. Stetson & Son.
Hinsdale,	Hinsdale Creamery Company.	W. C. Solomon, manager.
Lee,	Lee Co-operative,	P. A. Agnew, manager.
Leominster,	Leominster,	G. S. Wass & Co.
Montague,	Montague Creamery,	F. A. Rist, manager.
Monterey,	Berkshire Hills Co-operative.	D. A. Campbell, manager.
New Salem (P. O. Millington).	New Salem Co-operative,	W. A. Moore, superintendent.
North Brookfield,	North Brookfield,	H. A. Richardson.
Northfield,	Northfield Co-operative,	L. R. Smith, superintendent.
Orange (P. O. North Orange).	Orange Co-operative,	C. E. Dunbar, manager.
Sandisfield (P. O. New Boston).	Berkshire Co-operative,	L. A. Bonnel, manager.
Shelburne,	Shelburne,	C. Williams, manager.
Uxbridge,	Farnum's Dairy,	Geo. Farnum.
Warren,	Worcester County,	Gustal Hallberg, manager.
Westfield,	Wyben Spring Co-operative.	C. H. Wolcott, manager.
West Newbury,	West Newbury Co-operative.	R. S. Brown, manager.
Williamsburg,	Williamsburg Co-operative,	D. T. Clark, manager.
Worthington (P. O. Ringville).	Worthington Co-operative,	M. R. Bates, superintendent.

2. Milk Depots.

Location.	Name.	President or Manager.
Beverly,	Cherry Hill Farm,	Henry Fielden, superintendent.
Boston (P. O. Roxbury),	Alden Bros.,	
Boston (P. O. Charlestown).	Boston Dairy Company,	W. A. Graustein, president.
Boston (P. O. Charlestown).	H. P. Hood & Sons,	
Boston,	Walker-Gordon Laboratory.	R. A. Hubbard, manager.
Boston (P. O. Charlestown).	D. Whiting & Sons,	Geo. Whiting, manager.
Cambridge,	C. Brigham Company,	J. R. Blair, superintendent.
Conway,	Boston Dairy Company,	C. P. Hassel, manager.
Everett,	N. E. Dairy Company,	F. H. Adams, manager.
Framingham (P. O. South Framingham).	Echo Farm Dairy,	J. Turner.
Fitchburg,	Fitchburg Creamery,	G. S. Learned.
Gardner,	Boston Dairy Company,	W. Fitzsimmons, manager.
Groton,	Lawrence Creamery,	M. P. Swallow, manager.
Lynn,	H. P. Hood & Sons,	E. W. Park, manager.
Marlborough,	Este's Creamery,	F. S. Este.
North Adams,	W. H. Freeman Company,	W. G. McKay, manager.
Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
Southborough,	Deerfoot Farm Dairy,	S. H. Howes, superintendent.
Springfield,	Springfield Co-operative Milk Association.	F. B. Allen, manager.
Springfield,	Tait Bros.,	H. J. Tait, president.
West Stockbridge,	F. D. Shove Creamery,	C. E. Hardy, manager.
Worcester,	Wachusett Creamery,	E. H. Thayer & Co.
Worcester,	Worcester Dairy Company,	G. R. Bryant, manager.

The Testing of Pure-bred Cows.

Breeders of Jersey and Guernsey cows in Massachusetts continue to make yearly milk and butter fat tests of their stock under the rules of their respective national cattle clubs. This division of the station assists in the work by furnishing reputable parties who monthly visit each herd where tests are in progress, weigh each milking during twenty-four or forty-eight hours, and test the same by the Babcock for the butter fat percentage. The cost of such work consists of the tester's time at $2 to $2.50 a day, together with his travelling expenses, board and breakage. The station receives its pay from the Jersey or Guernsey clubs. There have been completed during the year 24 Guernsey and 38 Jersey records,

and at present there are 8 Guernseys and 32 Jerseys undergoing yearly tests. Tests are likewise being conducted for the National Holstein-Friesian Association. These are mostly seven-day tests for milk and butter fat. Occasionally breeders test their animals for thirty and even ninety days. The test of the Holstein cow De Kol Creamelle No. 59158, belonging to Mr. D. W. Field, which yielded in one hundred days 10,017 pounds of milk containing 284.088 pounds of fat, was made by Mr. A. D. Guiel of this station. During the year 72 Holsteins have been tested, requiring the services of five men at different times during the year. The station does not publish the results obtained, but reports the same to the several cattle clubs, and keeps a duplicate record on file. It must be understood that the making of appointments for tests, the furnishing of apparatus, the securing of the necessary competent men and the verifying of the results require considerable time and thought, and necessarily interfere with the other work of this department.

Work completed.

Molasses. — There has been completed a repeated experiment with Porto Rico molasses as a food for dairy stock. Digestion tests have likewise been made, in which it is shown that molasses depresses the digestibility of the other foods with which it is fed. The entire results will be published in bulletin form. Porto Rico molasses contains some 1,100 to 1,150 pounds of digestible matter to the ton, and has about 80 per cent. of the nutritive value of corn meal.

Digestion Experiments with Sheep. — A large number of digestion experiments have been completed with sheep, and are published as Part II. of this report. Among the feeds tested may be mentioned sorghum fodder, Green Diamond sugar feed, different amounts of molasses, red and white wheats and feed barley.

The Physiological and Economical Value of Protein in Milk Secretion. — Three experiments have been completed concerning the protein requirements of dairy cows, and it is intended to publish the results in the next annual report. It was not possible to collate the data and prepare the same for publication in time for the present report.

Work in Progress.

Alfalfa Meal. — An experiment is at present in progress to study the value of alfalfa meal as a substitute for wheat bran in milk production. It is understood to be the intention of feed jobbers in the near future to place alfalfa meal upon the market in liberal quantities as a competitor of bran, claiming it to be equal in feeding value and superior in its effect upon the general health and condition of the animal. The indications are that these claims cannot be fully substantiated.

The Effect of Molasses upon the Digestibility of Other Feed Stuffs. — German investigators have long since established the fact that the addition of considerable quantities of starch, sugar and roots depresses the digestibility of the other feeds entering into the composition of the ration. In our previous studies with Porto Rico molasses, as published elsewhere in this report, it has been shown that when molasses constituted some 25 per cent. of the dry matter of the ration, a depression of some 15 per cent. was caused in the digestibility of the latter. Other experiments are now in progress to note if smaller quantities of molasses (10 per cent. of the dry matter of the total ration) will cause relatively as large a depression as twice and thrice that amount.

The Digestibility of Proprietary Grain Rations. — Numerous grain mixtures are now upon the market as ready rations for dairy stock. The station is ascertaining the composition and particularly the digestibility of these rations as compared with home mixtures that the dairymen can prepare by purchasing the high-grade concentrates to be had in all local markets. It is believed that most of these proprietary mixtures are not as economical nor as efficient for milk production as the home mixtures.

Early Amber Sorghum. — The station has continued its observations with this plant as a summer forage crop. Different seedsmen report anywhere from 50 to 100 pounds of seed to be necessary for an acre when sown broadcast. Three twentieth-acre plots were fertilized alike, and the sorghum sown broadcast at the rate of 100, 80 and 60 pounds to the

acre. The yields were nearly identical in each case, being at the rate of 20 tons of green material to the acre (harvested September 3). On another twentieth-acre plot the seed was drilled in at the rate of 15 pounds to the acre, and a yield of 19 tons to the acre was secured. This plot, however, was very weedy, and it was not possible to separate the weeds from the sorghum before weighing the crop. It is evident that when sown broadcast (which appeared to be the most economical way for forage purposes) much less seed is required to the acre than is ordinarily recommended. It is intended to repeat these trials with smaller quantities of seed.

Alfalfa. — Observations have been continued on alfalfa as a forage crop. A small piece seeded in the spring of 1905 came through the winter in good condition, and yielded three crops the present season, aggregating 3.65 tons of hay to the acre (figured at 15 per cent. moisture). Cuttings were made June 25, August 3 and September 2. A growth of six or more inches has been allowed to remain as a mulch during the winter.

A second piece, one-sixth of an acre in area, on which alfalfa had been for two years previously, but which had run out, was plowed in the spring of 1906, manured at the rate of 6 cords to the acre, limed with burnt lime at the rate of 1 ton to the acre, a fine seed bed made, and seeded with seed procured from F. E. Dawley, Fayetteville, N. Y. (locally known as Stillwell seed), and a light seeding of oats (¾ bushel to the acre). The seed came up well, and the combined alfalfa and oats were cut during July for forage. A second cutting was made in September. A third growth of six inches has been left as a mulch. It remains to be seen if this piece as well as the other above mentioned will withstand the present winter, and continue to grow without being replaced by clover and grasses. A fuller report will be made later.

Leaming v. Pride of the North Corn. — The comparative values of these two standard varieties are being studied, to ascertain if one has any particular advantage over the other for grain and silage purposes. Accurate determinations of

composition and total yields, as well as of composition and yields of stalk, leaves, husks, grain and cob, have been made. The digestibility of the two varieties has also been determined. The experiment will be repeated if necessary during the season of 1907, and the completed data published as soon as possible thereafter.

Clover. — Clover was seeded together with peas and oats, barnyard millet and sorghum the present season, to see if it would not develop after these crops had been removed for soiling. If such were the case, it would save plowing and replanting, and the ground would be immediately occupied by another valuable forage crop. The clover came up well in all cases, but naturally was outstripped by the more rapidly growing annuals. After the three seedings of peas and oats had been successively cut, the clover began to grow; but a considerable growth of weeds and wild grasses also appeared, so that the heavy cutting which was made about the middle of September contained rather more grass than clover. It is possible that the clover will come in well in the spring. The millet and the sorghum grew so dense that the clover was nearly all killed out, hence it did not appear practicable to attempt its growth with such forage crops.

Changes in Staff.

Mr. S. R. Parker, who was employed for two years as dairy tester, resigned June 1, to accept a position as superintendent of agriculture at the Kamehameha Schools, Honolulu, H. T. His place was temporarily filled by the appointment of Mr. J. G. Cook, and later by Mr. H. A. Parsons, who at present fills the position most acceptably. On August 1 Mr. Cook resigned, to take the position of superintendent of the farm connected with the State Asylum for the Insane at Northampton. Mr. A. C. Whittier, who so acceptably filled the position of assistant chemist during one year, severed his connection with this division July 1, to accept a similar and more lucrative position with the Maine Experiment Station. This position was filled by the appointment of Mr. L. S. Walker, a graduate of the college in 1905. Mr. F. G. Helyar, inspector of feeds and of Babcock machines,

resigned October 1, to take charge of the agricultural department connected with Mt. Hermon School, Northfield, Mass. Mr. W. K. Hepburn has been appointed to succeed him. While the writer is always pleased to see the young men connected with this division called to more responsible positions, it must be acknowledged that such changes seriously interfere with the work of the station. As a rule, it is believed it would be better economy to pay larger salaries, and retain the services of those who have proved themselves efficient workers.

Part II. — Work in Animal Nutrition.

J. B. LINDSEY, E. B. HOLLAND AND P. H. SMITH.

The Digestibility of Cattle Foods.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1904–05 and 1905–06, and are known as Series X and XI. The usual method was employed, an illustrated description of which is to be found in the eleventh report of the Massachusetts Experiment Station. The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were given each sheep daily, with water *ad libitum*. Three lots of Southdown wethers were employed in the several trials, and were known as the Old Sheep, Young Sheep, and Paige Sheep. The former were fully six years of age, and the latter two lots three to four years.

Series X.

The results obtained in this series on the whole can be pronounced satisfactory. In periods I., II., III. and IV. the same hay was used as in the year preceding, and the digestion coefficients employed in calculating the results of these several periods were as follows: [1] —

[1] See also seventeenth report of this station, page 46.

	Old Sheep II. and III.	Young Sheep I.	Young Sheep II.	Young Sheep III.
Dry matter,	58.50	49.89	54.34	51.53
Ash,	22.00	13.86	22.60	16.55
Protein,	42.50	37.37	37.72	36.36
Fiber,	61.00	49.98	55.85	53.13
Nitrogen-free extract,	64.00	56.29	59.77	57.02
Fat,	46.50	38.24	44.19	36.97

In all of the remaining periods a new lot of hay was used, and the following coefficients were employed, being the average of those secured for each group of sheep: —

	Old Sheep.	Young Sheep.	Paige Sheep.
Dry matter,	60.72	57.07	57.98
Ash,	45.50	43.64	40.52
Protein,	53.69	47.37	53.61
Fiber,	63.79	57.55	59.06
Nitrogen-free extract,	63.08	61.11	61.41
Fat,	50.24	51.71	47.76

The composition of the old hay used in the first four periods was taken to be the same as was shown by the two analyses made in the preceding year. The composition of the new hay represents the average of three analyses. The average of the several analyses follows: —

	Old Hay, **1903–04.**	New Hay, **1904–05.**
Ash,	6.44	8.20
Protein,	6.24	8.69
Fiber,	32.48	32.14
Nitrogen-free extract,	52.70	48.56
Fat,	2.14	2.41

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Soy bean fodder,	9.17	21.69	27.83	37.75	3.56
Blomo feed,	10.73	17.23	13.14	58.28	0.62
Malt sprouts,	6.58	28.65	15.29	47.70	1.78
Sucrene dairy feed,	6.17	18.48	14.11	56.95	4.29
Holstein sugar feed,	7.31	13.73	10.88	65.14	2.94
Macon sugar feed,	6.83	15.16	10.20	66.11	1.70
Hominy feed,	2.78	11.59	5.28	71.54	8.81
Buckwheat middlings,	4.82	28.23	8.95	50.61	7.39
Oat middlings,	2.61	17.72	2.56	69.47	7.64
Eureka silage corn stover,	6.96	8.00	36.49	47.16	1.39
Waste Eureka silage corn stover, Sheep II.,	8.50	6.71	41.89	41.89	1.01
Waste Eureka silage corn stover, Sheep III.,	7.45	6.02	42.84	42.48	1.21
Pride of the North corn stover,	6.77	7.23	34.45	50.01	1.54
Waste Pride of the North corn stover, Sheep II.	7.64	4.27	40.94	45.65	1.50
Waste Pride of the North corn stover, Sheep III.	6.88	3.76	40.74	47.14	1.48
Digestion hay fed to Paige Sheep IV.,	7.82	8.56	32.35	48.75	2.52
Digestion hay fed to Young Sheep,	8.43	8.70	32.17	48.33	2.37
Digestion hay fed to Old Sheep and Paige Sheep V.	8.35	8.80	31.89	48.62	2.34
Average for digestion hay (three trials),	8.20	8.69	32.14	48.56	2.41

Composition of Fæces (Per Cent.).

[Dry Matter.]

Old Sheep II.

Periods.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
II.,	Blomo feed,	15.41	11.93	25.59	44.81	2.26
IV.,	Sucrene feed,	11.92	12.32	26.50	47.05	2.21
V.,	Eureka silage corn stover,	7.96	8.75	34.10	48.16	1.03
VII.,	Pride of the North corn stover,	9.54	8.81	30.27	50.17	1.21
IX.,	Digestion hay,	11.48	10.22	29.56	45.71	3.03
XI.,	Macon sugar feed,	13.17	12.90	27.09	44.26	2.58

Composition of Fæces (Per Cent.) — Concluded.

Periods.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
	Old Sheep III.					
II.,	Blomo feed,	16.33	13.38	23.99	43.92	2.38
IV.,	Sucrene feed,	12.53	13.04	24.84	47.34	2.25
V.,	Eureka silage corn stover,	8.67	9.73	30.51	50.05	1.04
VII.,	Pride of the North corn stover,	10.62	9.41	27.95	50.84	1.18
IX.,	Digestion hay,	11.68	10.52	29.23	45.67	2.90
XI.,	Macon sugar feed,	13.57	13.75	26.40	43.90	2.38
	Young Sheep I.					
I.,	Soy bean fodder,	13.22	10.02	36.33	37.43	3.00
III.,	Malt sprouts,	12.97	11.19	27.80	45.42	2.62
VIII.,	Digestion hay,	10.92	10.26	32.09	44.01	2.72
X.,	Holstein sugar feed,	13.10	12.80	28.36	43.50	2.24
XIII.,	Buckwheat middlings,	11.52	11.74	32.08	41.79	2.87
	Young Sheep II.					
I.,	Soy bean fodder,	13.19	10.36	36.24	37.20	3.01
III.,	Malt sprouts,	13.11	11.72	26.74	45.93	2.50
VIII.,	Digestion hay,	11.57	11.18	30.46	44.06	2.73
X.,	Holstein sugar feed,	13.06	12.80	27.49	44.32	2.33
XIII.,	Buckwheat middlings,	11.23	12.84	31.65	41.58	2.70
	Young Sheep III.					
I.,	Soy bean fodder,	13.40	9.72	36.36	37.64	2.88
III.,	Malt sprouts,	12.93	11.20	28.13	45.28	2.46
VIII.,	Digestion hay,	10.75	10.60	32.81	43.29	2.55
X.,	Holstein sugar feed,	11.65	11.42	30.23	44.41	2.29
XIII.,	Buckwheat middlings,	10.62	11.31	32.98	42.26	2.83
	Paige Sheep IV.					
VI.,	Digestion hay,	11.61	9.90	30.66	44.91	2.92
XII.,	Hominy feed,	12.17	12.75	27.63	43.68	3.77
XIV.,	Oat middlings,	12.52	12.52	28.81	42.82	3.33
	Paige Sheep V.					
IX.,	Digestion hay,	11.23	9.24	31.93	44.49	3.11
XII.,	Hominy feed,	11.02	11.69	28.64	44.93	3.72
XIV.,	Oat middlings,	11.81	12.39	29.35	43.31	3.14

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Manure excreted, determined from Air-dry Fæces (Per Cent.).

Old Sheep II.

Periods.	English Hay.	Blomo Feed.	Sucrene Feed.	Eureka Silage Corn Stover.	Pride of the North Corn Stover.	Macon Sugar Feed.	Waste.	Fæces.
II., . .	87.70	81.77	–	–	–	–	–	91.35
IV., . .	87.35	–	86.87	–	–	–	–	93.61
V., . .	–	–	–	37.11	–	–	43.15	94.16
VII., . .	–	–	–	–	81.87	–	88.89	94.22
IX., . .	89.77	–	–	–	–	–	–	95.03
XI., . .	90.30	–	–	–	–	94.45	–	93.96

Old Sheep III.

II., . .	87.70	81.77	–	–	–	–	–	91.42
IV., . .	87.35	–	86.87	–	–	–	–	93.64
V., . .	–	–	–	37.11	–	–	45.63	93.96
VII., . .	–	–	–	–	81.87	–	85.63	94.03
IX., . .	89.77	–	–	–	–	–	–	94.84
XI., . .	90.30	–	–	–	–	94.45	–	93.57

Dry Matter Determinations, etc. — Continued.

Young Sheep I.

Periods.	English Hay.	Soy Bean Fodder.	Malt Sprouts.	Holstein Sugar Feed.	Buckwheat Middlings.	Waste.	Fæces.
I., ...	88.40	20.64	–	–	–	–	89.51
III., ...	88.02	–	84.68	–	–	–	93.09
VIII., ...	88.52	–	–	–	–	–	93.97
X., ...	89.90	–	–	91.66	–	–	94.15
XIII., ...	90.55	–	–	–	90.74	–	94.40

Young Sheep II.

I., ...	88.40	20.64	–	–	–	–	89.44
III., ...	88.02	–	84.68	–	–	–	92.93
VIII., ...	88.52	–	–	–	–	–	94.01
X., ...	89.90	–	–	91.66	–	–	94.19
XIII., ...	90.55	–	–	–	90.74	–	93.91

Dry Matter Determinations, etc. — Continued.

Young Sheep III.

Periods.	English Hay.	Soy Bean Fodder.	Malt Sprouts.	Holstein Sugar Feed.	Buckwheat Middlings.	Waste.	Fæces.
I., ...	88.40	20.64	–	–	–	–	89.54
IV., ...	88.02	–	84.68	–	–	–	93.13
VIII., ...	88.52	–	–	–	–	–	93.91
X., ...	89.90	–	–	91.66	–	–	94.35
XIII., ...	90.55	–	–	–	90.74	–	94.28

Dry Matter Determinations, etc. — Concluded.

Paige Sheep IV.

Periods.	English Hay.	Hominy Feed.	Oat Middlings.	Waste.	Fæces.
VI., ...	88.35	–	–	–	93.35
XII., ...	90.62	90.94	–	–	94.09
XIV., ...	90.45	–	91.07	–	93.73
Paige Sheep V.					
IX., ...	89.77	–	–	–	95.08
XII., ...	90.62	90.94	–	–	94.20
XIV., ...	90.45	–	91.07	–	93.52

Average Daily Amount of Manure excreted and Water drank (Grams).

Old Sheep II.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
II.,	Blomo feed, ...	671	32.80	1,306
IV.,	Sucrene feed, ...	751	31.15	1,144
V.,	Eureka silage corn stover, ...	765	31.07	lost.
VII.,	Pride of the North corn stover, ...	1,058	37.63	1,667
IX.,	Digestion hay, ...	775	32.54	1,643
XI.,	Macon sugar feed, ...	739	31.99	1,592
	Old Sheep III.			
II.,	Blomo feed, ...	675	30.83	1,578
IV.,	Sucrene feed, ...	867	32.31	1,606
V.,	Eureka silage corn stover, ...	921	28.91	804
VII.,	Pride of the North corn stover, ...	1,123	34.40	2,500
IX.,	Digestion hay, ...	1,107	34.30	2,430
XI.,	Macon sugar feed, ...	1,155	31.21	2,227

Average Daily Amount of Manure excreted and Water drank (Grams) — Concluded.

Young Sheep I.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder,	615	30.28	188
III.,	Malt sprouts,	870	30.43	1,392
VIII.,	Digestion hay,	961	33.17	1,693
X.,	Holstein sugar feed,	1,008	29.21	1,608
XIII.,	Buckwheat middlings,	743	28.62	1,689

Young Sheep II.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder,	573	30.70	1,169
III.,	Malt sprouts,	746	30.48	2,334
VIII.,	Digestion hay,	984	30.86	2,471
X.,	Holstein sugar feed,	868	28.04	2,249
XIII.,	Buckwheat middlings,	882	27.91	2,410

Young Sheep III.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder,	638	32.68	1,666
III.,	Malt sprouts,	791	30.86	2,486
VIII.,	Digestion hay,	1,152	33.02	2,500
X.,	Holstein sugar feed,	743	29.30	2,335
XIII.,	Buckwheat middlings,	699	29.59	2,486

Paige Sheep IV.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
VI.,	Digestion hay,	678	32.15	1,138
IX.,	Digestion hay,	–	–	–
XII.,	Hominy feed,	596	25.37	1,901
XIV.,	Oat middlings,	598	24.85	1,924

Paige Sheep V.

Periods.	Character of Ration.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
VI.,	Digestion hay,	–	–	–
IX.,	Digestion hay,	699	31.41	1,924
XII.,	Hominy feed,	630	26.31	1,666
XIV.,	Oat middlings,	661	25.85	1,814

Weights of Animals at Beginning and End of Period (Pounds).

Old Sheep II.

Periods.	Character of Ration.	Beginning.	End.
II.,	Blomo feed, ...	154.75	152.00
IV.,	Sucrene feed, ...	156.50	157.75
V.,	Eureka silage corn stover, ...	156.50	154.00
VII.,	Pride of the North corn stover, ...	154.50	157.00
IX.,	Digestion hay, ...	158.25	157.25
XI.,	Macon sugar feed, ...	160.00	157.75

Old Sheep III.

Periods.	Character of Ration.	Beginning.	End.
II.,	Blomo feed, ...	163.00	160.00
IV.,	Sucrene feed, ...	164.25	162.25
V.,	Eureka silage corn stover, ...	163.25	163.00
VII.,	Pride of the North corn stover, ...	164.50	161.00
IX.,	Digestion hay, ...	167.00	165.25
XI.,	Macon sugar feed, ...	164.00	164.25

Young Sheep I.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	101.50	99.75
III.,	Malt sprouts, ...	109.50	109.75
VIII.,	Digestion hay, ...	120.00	116.00
X.,	Holstein sugar feed, ...	116.00	114.25
XIII.,	Buckwheat middlings, ...	113.00	114.00

Young Sheep II.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	102.50	101.00
III.,	Malt sprouts, ...	110.50	108.50
VIII.,	Digestion hay, ...	122.00	120.00
X.,	Holstein sugar feed, ...	115.75	116.00
XIII.,	Buckwheat middlings, ...	115.25	116.00

Young Sheep III.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	97.00	95.75
III.,	Malt sprouts, ...	102.25	101.50
VIII.,	Digestion hay, ...	111.00	107.50
X.,	Holstein sugar feed, ...	106.00	106.00
XIII.,	Buckwheat middlings, ...	106.50	106.50

Weights of Animals, etc. — Concluded.

Paige Sheep IV.

Periods.	Character of Ration.	Beginning.	End.
VI.,	Digestion hay,	156.00	155.50
IX.,	Digestion hay,	–	–
XII.,	Hominy feed,	154.50	152.00
XIV.,	Oat middlings,	155.50	155.00

Paige Sheep V.

VI.,	Digestion hay,	–	–
IX.,	Digestion hay,	133.25	137.75
XII.,	Hominy feed,	140.00	140.25
XIV.,	Oat middlings,	141.00	143.25

Period I.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
350 grams English hay fed,	309.40	19.93	19.31	100.49	163.05	6.62
1,800 grains soy bean fodder fed,	371.52	34.07	80.58	103.39	140.25	13.23
Amount consumed,	680.92	54.00	99.89	203.88	303.30	19.85
302.84 grams manure excreted,	271.07	35.84	27.16	98.48	101.46	8.13
Grams digested,	409.85	18.16	72.73	105.40	201.84	11.72
Minus hay digested,	154.36	2.76	7.22	50.22	91.78	2.55
Soy bean fodder digested,	255.49	15.40	65.51	55.18	110.06	9.17
Per cent. digested,	68.77	45.20	81.30	53.37	78.47	69.31

Young Sheep II.

Amount consumed as above,	680.92	54.00	99.89	203.88	303.30	19.85
307.13 grams manure excreted,	274.70	36.23	28.46	99.55	102.19	8.27
Grams digested,	406.22	17.77	71.43	104.33	201.11	11.58
Minus hay digested,	168.13	4.50	7.28	56.12	97.45	2.93
Soy bean fodder digested,	238.09	13.27	64.15	48.21	103.66	8.65
Per cent. digested,	64.09	38.95	79.61	46.63	73.91	65.38

Period I. — Concluded.

Young Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	680.92	54.00	99.89	203.88	303.30	19.85
326.78 grams manure excreted,	292.60	39.21	28.44	106.39	110.13	8.43
Grams digested,	388.32	14.79	71.45	97.49	193.17	11.42
Minus hay digested,	159.43	3.30	7.08	53.39	92.97	2.45
Soy bean fodder digested,	228.89	11.49	64.37	44.10	100.20	8.97
Per cent. digested,	61.61	33.72	79.88	42.65	71.44	67.80
Average per cent. three sheep digested,	64.82	39.29	80.26	47.55	74.61	67.50

Average nutritive ratio of rations for three sheep, 1:4.54.

Period II.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	438.50	28.24	27.36	142.42	231.09	9.38
400 grams Blomo feed fed,	327.08	35.10	56.36	42.98	190.62	2.03
Amount consumed,	765.58	63.34	83.72	185.40	421.71	11.41
328.04 grams manure excreted,	299.66	46.18	35.75	76.68	134.28	6.77
Grams digested,	465.92	17.16	47.97	108.72	287.43	4.64
Minus hay digested,	256.52	6.21	11.63	86.88	147.90	4.36
Blomo feed digested,	209.40	10.95	36.34	21.84	139.53	.28
Per cent. digested,	64.02	31.20	64.48	50.81	73.20	13.79

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	765.58	63.34	83.72	185.40	421.71	11.41
308.33 grams manure excreted,	281.88	46.03	37.72	67.62	123.80	6.71
Grams digested,	483.70	17.31	46.00	117.78	297.91	4.70
Minus hay digested,	256.52	6.21	11.63	86.88	147.90	4.36
Blomo feed digested,	227.18	11.10	34.37	30.90	150.01	.34
Per cent. digested,	69.46	31.62	60.98	71.89	78.70	16.75
Average per cent. two sheep digested,	66.74	31.41	62.73	61.35	75.95	15.27

Average nutritive ratio of rations for two sheep, 1:8.86.

Period III.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	528.12	34.01	32.95	171.53	278.32	11.30
200 grams malt sprouts fed,	169.36	11.14	48.52	25.90	80.78	3.01
Amount consumed,	697.48	45.15	81.47	197.43	359.10	14.31
304.24 grams manure excreted,	283.22	36.73	31.69	78.74	128.64	7.42
Grams digested,	414.26	8.42	49.78	118.69	230.46	6.89
Minus hay digested,	263.48	4.71	12.31	85.73	156.67	4.32
Malt sprouts digested,	150.78	3.71	37.47	32.96	73.79	2.57
Per cent. digested,	89.03	33.30	77.23	100+	91.35	85.38

Young Sheep II.

Amount consumed as above,	697.48	45.15	81.47	197.43	359.10	14.31
304.81 grams manure excreted,	283.26	37.14	33.20	75.74	130.10	7.08
Grams digested,	414.22	8.01	48.27	121.69	229.00	7.23
Minus hay digested,	286.98	7.69	12.43	95.80	166.35	4.99
Malt sprouts digested,	127.24	.32	35.84	25.89	62.65	2.24
Per cent. digested,	75.13	2.87	73.87	100.00	77.56	74.42

Young Sheep III.

Amount consumed as above,	697.48	45.15	81.47	197.43	359.10	14.31
308.60 grams manure excreted,	287.40	37.16	32.19	80.85	130.13	7.07
Grams digested,	410.08	7.99	49.28	116.56	228.97	7.24
Minus hay digested,	272.14	5.63	12.08	91.13	158.70	4.18
Malt sprouts digested,	137.94	2.36	37.20	25.45	70.27	3.06
Per cent. digested,	81.45	21.18	76.67	98.26	86.99	100+
Average per cent. three sheep digested,	81.87	19.12	75.92	99.42	85.30	86.60

Average nutritive ratio of rations for three sheep, 1:7.42.

Period IV.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed, . . .	524.10	33.75	32.70	170.23	276.20	11.22
300 grams Sucrene dairy feed fed, .	260.61	16.08	48.16	36.77	148.42	11.18
Amount consumed, ...	784.71	49.83	80.86	207.00	424.62	22.40
311.47 grams manure excreted, . .	291.57	34.76	35.92	77.27	137.18	6.44
Grams digested, ...	493.14	15.07	44.94	129.73	287.44	15.96
Minus hay digested, ...	306.60	7.43	13.90	103.84	176.77	5.22
Sucrene dairy feed digested, . . .	186.54	7.64	31.04	25.89	110.67	10.74
Per cent. digested, ...	71.58	47.51	64.45	70.41	74.57	96.06

Old Sheep III.

Amount consumed as above, . . .	784.71	49.83	80.86	207.00	424.62	22.40
323.07 grams manure excreted, . .	302.52	37.91	39.45	75.15	143.21	6.81
Grams digested, ...	482.19	11.92	41.41	131.85	281.41	15.59
Minus hay digested, ...	306.60	7.43	13.90	103.84	176.77	5.22
Sucrene dairy feed digested, . . .	175.59	4.49	27.51	27.01	104.64	10.37
Per cent. digested, ...	67.38	27.92	57.12	73.46	70.50	92.75
Average per cent. two sheep digested, .	69.48	37.72	60.79	71.94	72.54	94.41

Average nutritive ratio of rations for two sheep, 1 : 10.4.

Period V.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,800 grams Eureka silage corn stover,	667.98	46.49	53.44	243.75	315.02	9.28
Minus 89 grams waste, ...	38.40	3.26	2.58	16.09	16.09	.38
Amount consumed, ...	629.58	43.23	50.86	227.66	298.93	8.90
310.74 grams manure excreted, . .	292.59	23.29	25.60	99.77	140.91	3.01
Grams digested, ...	336.99	19.94	25.26	129.89	158.02	5.89
Per cent. digested, ...	53.53	46.13	49.67	56.18	52.86	66.18

Period V. — Concluded.

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,800 grams Eureka silage corn stover,	667.98	46.49	53.44	243.75	315.02	9.28
Minus 133.20 grams waste, ...	60.78	4.53	3.66	26.04	25.82	0.74
Amount consumed, ...	607.20	41.96	49.78	217.71	289.20	8.54
289.07 grams manure excreted, . .	271.61	23.55	26.43	82.87	135.94	2.82
Grams digested, ...	335.59	18.41	23.35	134.84	153.26	5.72
Per cent. digested, ...	55.27	43.88	46.91	61.94	52.99	66.98
Average per cent. two sheep digested,	54.40	45.01	48.29	59.06	52.93	66.58

Average nutritive ratio of rations for two sheep, 1:12.3.

Period VI.

Paige Sheep IV.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, ...	706.80	55.27	60.50	228.65	344.57	17.81
321.50 grams manure excreted, . .	300.12	34.84	29.71	92.02	134.78	8.76
Grams digested, ...	406.68	20.43	30.79	136.63	209.79	9.05
Per cent. digested, ...	57.54	36.96	50.89	59.76	60.88	50.81

Nutritive ratio of ration, 1:11.9.

Period VII.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,000 grams Pride of the North corn stover.	818.70	55.43	59.19	282.04	409.43	12.61
Minus 74.64 grams waste, ...	66.35	5.07	2.83	27.16	30.29	1.00
Amount consumed, ...	752.35	50.36	56.36	254.88	379.14	11.61
376.31 grams manure excreted, . .	354.56	33.83	31.24	107.33	177.88	4.29
Grams digested, ...	397.79	16.53	25.12	147.55	201.26	7.32
Per cent. digested, ...	52.87	32.82	44.57	57.89	53.08	63.05

Period VII. — Concluded.

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,000 grams Pride of the North corn stover.	818.70	55.43	59.19	282.04	409.43	12.61
Minus 115.45 grams waste,	98.86	6.80	3.72	40.28	46.60	1.46
Amount consumed,	719.84	48.63	55.47	241.76	362.83	11.15
344.01 grams manure excreted,	323.47	34.35	30.44	90.41	164.45	3.82
Grams digested,	396.37	14.28	25.03	151.35	198.38	7.33
Per cent. digested,	55.06	29.36	45.12	62.60	54.68	65.75
Average per cent. two sheep digested,	53.97	31.09	44.85	60.25	53.88	64.40

Average nutritive ratio of rations for two sheep, 1:14.6.

Period VIII.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
331.74 grams manure excreted,	311.74	34.04	31.98	100.04	137.20	8.48
Grams digested,	396.42	25.66	29.63	127.78	205.05	8.30
Per cent. digested,	55.98	42.98	48.09	56.09	59.91	49.46

Young Sheep II.

800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
308.60 grams manure excreted,	290.11	33.57	32.43	88.37	127.82	7.92
Grams digested,	418.05	26.13	29.18	139.45	214.43	8.86
Per cent. digested,	59.03	43.77	47.36	61.21	62.65	52.80

Young Sheep III.

800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
330.18 grams manure excreted,	310.07	33.33	32.87	101.73	134.23	7.91
Grams digested,	398.09	26.37	28.74	126.09	208.02	8.87
Per cent. digested,	56.21	44.17	46.65	55.35	60.78	52.86
Average per cent. three sheep digested,	57.07	43.64	47.37	57.55	61.11	51.71

Average nutritive ratio of rations for three sheep, 1:12.3.

Period IX.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay fed,	807.93	67.46	71.10	257.65	392.82	18.91
325.43 grams manure excreted,	309.26	35.50	31.61	91.42	141.36	9.37
Grams digested,	498.67	31.96	39.49	166.23	251.46	9.54
Per cent. digested,	61.72	47.36	55.54	64.52	64.01	50.45

Old Sheep III.

900 grams English hay fed,	807.93	67.46	71.10	257.65	392.82	18.91
343 grams manure excreted,	325.30	38.00	34.22	95.09	148.56	9.43
Grams digested,	482.63	29.46	36.88	162.56	244.26	9.47
Per cent. digested,	59.74	43.67	51.87	63.09	62.18	50.08

Paige Sheep V.

800 grams English hay fed,	718.16	59.97	63.20	229.02	349.17	16.80
314.13 grams manure excreted,	298.67	33.54	27.60	95.37	132.88	9.29
Grams digested,	419.49	26.43	35.60	133.65	216.29	7.51
Per cent. digested,	58.41	44.07	56.33	58.36	61.94	44.70
Average per cent. three sheep digested,	60.73	45.52	53.71	63.81	63.10	50.27

Average nutritive ratio of rations for three sheep, 1 : 11.3.

Period X.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	449.50	36.86	39.06	144.47	218.28	10.83
300 grams Holstein sugar feed,	274.98	20.10	37.75	29.92	179.12	8.08
Amount consumed,	724.48	56.96	76.81	174.39	397.40	18.91
292.11 grams manure excreted,	275.02	36.03	35.20	78.00	119.63	6.16
Grams digested,	449.46	20.93	41.61	96.39	277.77	12.75
Minus hay digested,	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested,	192.93	4.84	23.11	13.25	144.38	7.15
Per cent. digested,	70.16	24.08	61.22	44.28	80.61	88.49

Period X. — Concluded.

Young Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . . .	724.48	56.96	76.81	174.39	397.40	18.91
280.41 grams manure excreted, . .	264.12	34.49	33.81	72.61	117.06	6.15
Grams digested, ...	460.36	22.47	43.00	101.78	280.34	12.76
Minus hay digested, ...	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested, . .	203.83	6.38	24.50	18.64	146.95	7.16
Per cent. digested, ...	74.13	31.74	64.90	62.30	82.04	88.61

Young Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . . .	724.48	56.96	76.81	174.39	397.40	18.91
293.03 grams manure excreted, . .	276.47	32.21	31.57	83.58	122.78	6.33
Grams digested, ...	448.01	24.75	45.24	90.81	274.62	12.58
Minus hay digested, ...	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested, . .	191.48	8.66	26.74	7.67	141.23	6.98
Per cent. digested, ...	69.63	43.08	70.83	25.64	78.85	86.39
Average per cent. three sheep digested,	71.31	32.97	65.65	44.07	80.50	87.83

Average nutritive ratio of rations for three sheep, 1:9.3.

Period XI.

Old Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed, . . .	541.80	44.43	47.08	174.13	263.10	13.06
300 grams Macon sugar feed, . .	283.35	19.35	42.96	28.90	187.32	4.82
Amount consumed, ...	825.15	63.78	90.04	203.03	450.42	17.88
319.90 grams manure excreted, . .	300.58	39.59	38.77	81.43	133.04	7.75
Grams digested, ...	524.57	24.19	51.27	121.60	317.38	10.13
Minus hay digested, ...	328.98	20.22	25.28	111.08	165.96	6.56
Macon sugar feed digested, . . .	195.59	3.97	25.99	10.52	151.42	3.57
Per cent. digested, ...	69.03	20.52	60.50	36.40	80.83	74.07

Period XI. — Concluded.

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . . .	825.15	63.78	90.04	203.03	450.42	17.88
312.14 grams manure excreted, . .	292.07	39.63	40.16	77.11	128.22	6.95
Grams digested, ...	533.08	24.15	49.88	125.92	322.20	10.93
Minus hay digested, ...	328.98	20.22	25.28	111.08	165.96	6.56
Macon sugar feed digested, . . .	204.10	3.93	24.60	14.84	156.24	4.37
Per cent. digested, ...	72.03	20.31	57.26	51.35	83.41	90.66
Average per cent. two sheep digested,	70.53	20.42	58.88	43.88	82.12	82.37

Average nutritive ratio of rations for two sheep, 1:9.2.

Period XII.

Paige Sheep IV.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . . .	498.41	40.87	43.31	160.19	242.03	12.01
300 grams hominy feed, ...	272.22	7.57	31.55	14.37	194.75	23.98
Amount consumed, ...	770.63	48.44	74.86	174.56	436.78	35.99
253.67 grams manure excreted, . .	238.68	29.05	30.43	65.95	104.26	9.00
Grams digested, ...	531.95	19.39	44.43	108.61	332.52	26.99
Minus hay digested, ...	288.98	16.56	23.22	94.61	148.63	5.74
Hominy feed digested, ...	242.97	2.83	21.21	14.00	183.89	21.25
Per cent. digested, ...	89.26	37.38	67.23	97.43	94.42	88.62

Paige Sheep V.

Amount consumed as above, . . .	770.63	48.44	74.86	174.56	436.78	35.99
263.07 grams manure excreted, . .	247.81	27.31	28.97	70.97	111.34	9.22
Grams digested, ...	522.82	21.13	45.89	103.59	325.44	26.77
Minus hay digested, ...	288.98	16.56	23.22	94.61	148.63	5.74
Hominy feed digested, ...	233.84	4.57	22.67	8.98	176.81	21.03
Per cent. digested, ...	85.90	60.37	71.85	62.49	90.79	87.70
Average per cent. two sheep digested,	87.58	48.88	69.54	79.96	92.61	88.16

Average nutritive ratio of rations for two sheep, 1:10.9.

Period XIII.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	498.03	40.84	43.28	160.07	241.84	12.00
250 grams buckwheat middlings,	226.85	10.93	64.04	20.30	114.81	16.76
Amount consumed,	724.88	51.77	107.32	180.37	356.65	28.76
286.23 grams manure excreted,	270.20	31.13	31.72	86.68	112.92	7.75
Grams digested,	454.68	20.64	75.60	93.69	243.73	21.01
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	170.45	2.82	55.10	1.57	95.94	14.80
Per cent. digested,	75.14	25.80	86.04	7.73	83.56	88.31

Young Sheep II.

Amount consumed as above,	724.88	51.77	107.32	180.37	356.65	28.76
279.07 grams manure excreted,	262.07	29.43	33.65	82.95	108.97	7.08
Grams digested,	462.81	22.34	73.67	97.42	247.68	21.68
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	178.58	4.52	53.17	5.30	99.89	15.47
Per cent. digested,	78.72	41.35	83.03	26.11	87.00	92.30

Young Sheep III.

Amount consumed as above,	724.88	51.77	107.32	180.37	356.65	28.76
295.90 grams manure excreted,	278.97	29.63	31.55	92.00	117.89	7.89
Grams digested,	445.91	22.14	75.77	88.37	238.76	20.87
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	161.68	4.32	55.27	–	90.97	14.66
Per cent. digested,	71.27	39.52	86.31	–	79.24	87.47
Average per cent. three sheep digested,	75.04	35.56	85.13	16.92[1]	83.27	89.36

Average nutritive ratio of rations for three sheep, 1: 5.1.

[1] Average two sheep.

Period XIV.

Paige Sheep IV.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	497.48	40.79	43.23	159.89	241.58	11.99
300 grams oat middlings,	273.21	7.13	48.41	6.99	189.80	20.87
Amount consumed,	770.69	47.92	91.64	166.88	431.38	32.86
248.47 grams manure excreted,	232.89	29.16	29.16	67.10	99.72	7.76
Grams digested,	537.80	18.76	62.48	99.78	331.66	25.10
Minus hay digested,	288.44	16.53	23.18	94.43	148.35	5.73
Oat middlings digested,	249.36	2.23	39.30	5.35	183.31	19.37
Per cent. digested,	91.27	31.28	81.18	76.54	96.58	92.81

Paige Sheep V.

Amount consumed as above,	770.69	47.92	91.64	166.88	431.38	32.86
258.53 grams manure excreted,	241.78	28.55	29.96	70.96	104.71	7.59
Grams digested,	528.91	19.37	61.68	95.92	326.67	25.27
Minus hay digested,	288.44	16.53	23.18	94.43	148.35	5.73
Oat middlings digested,	240.47	2.84	38.50	1.49	178.32	19.54
Per cent. digested,	88.02	39.83	79.53	21.32	93.95	93.63
Average per cent. two sheep digested,	89.65	35.56	80.36	48.93	95.27	93.22

Average nutritive ratio of rations for two sheep, 1:7.8.

Summary of Coefficients.

Coefficients determined on —	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Soybean fodder,	Young Sheep I.,	68.77	45.20	81.30	53.37	78.47	69.31
	Young Sheep II.,	64.09	38.95	79.61	46.63	73.91	65.38
	Young Sheep III.,	61.61	33.72	79.88	42.65	71.44	67.80
	Average,	64.82	39.29	80.26	47.55	74.61	67.50
Blomo feed,	Old Sheep II.,	64.02	31.20	64.48	50.81	73.20	13.79
	Old Sheep III.,	69.46	31.62	60.98	71.89	78.70	16.75
	Average,	66.74	31.41	62.73	61.35	75.95	15.27
Malt sprouts,	Young Sheep I.,	89.03	33.30	77.23	100+	91.35	85.38
	Young Sheep II.,	75.13	2.87	73.87	100+	77.56	74.42
	Young Sheep III.,	81.45	21.18	76.67	98.26	86.99	100+
	Average,	81.87	19.12	75.92	99.42	85.30	86.60
Sucrene dairy feed.	Old Sheep II.,	71.58	47.51	64.45	70.41	74.57	96.06
	Old Sheep III.,	67.38	27.92	57.12	73.46	70.50	92.75
	Average,	69.48	37.72	60.79	71.94	72.54	94.41

Summary of Coefficients — Concluded.

Coefficients determined on —	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Holstein sugar feed.	Young Sheep I., .	70.16	24.08	61.22	44.28	80.61	88.49
	Young Sheep II.,	74.13	31.74	64.90	62.30	82.04	88.61
	Young Sheep III.,	69.63	43.08	70.83	25.64	78.85	86.39
	Average, . .	71.31	32.97	65.65	44.07	80.50	87.83
Macon sugar feed.	Old Sheep II., .	69.03	20.52	60.50	36.40	80.83	74.07
	Old Sheep III., .	72.03	20.31	57.26	51.35	83.41	90.66
	Average, . .	70.53	20.42	58.88	43.88	82.12	82.37
Hominy feed, .	Paige Sheep IV.,	89.26	37.38	67.23	97.43	94.42	88.62
	Paige Sheep V., .	85.90	60.37	71.85	62.49	90.79	87.70
	Average, . .	87.58	48.88	69.54	79.96	92.61	88.16
Buckwheat middlings.	Young Sheep I., .	75.14	25.80	86.04	7.73	83.56	88.31
	Young Sheep II.,	78.72	41.35	83.03	26.11	87.00	92.30
	Young Sheep III.,	71.27	39.52	86.31	–	79.24	87.47
	Average, . .	75.04	35.56	85.13	16.92	83.27	89.36
Oat middlings,	Paige Sheep IV.,	91.27	31.28	81.18	76.54	96.58	92.81
	Paige Sheep V., .	88.02	39.83	79.53	21.32	93.95	93.63
	Average, . .	89.65	35.56	80.36	48.93	95.27	93.22
Eureka silage corn stover.	Old Sheep II., .	53.53	46.13	49.67	56.18	52.86	66.18
	Old Sheep III., .	55.27	43.88	46.91	61.94	52.99	66.98
	Average, . .	54.40	45.01	48.29	59.06	52.93	66.58
Pride of the North corn stover.	Old Sheep II., .	52.87	32.82	44.57	57.89	53.08	63.05
	Old Sheep III., .	55.06	29.36	45.12	62.60	54.68	65.75
	Average, . .	53.97	31.09	44.85	60.25	53.88	64.40
English hay, .	Paige Sheep IV.,	57.54	36.96	50.89	59.76	60.88	50.81
	Paige Sheep V., .	58.41	44.07	56.33	58.36	61.94	44.70
	Average, . .	57.98	40.52	53.61	59.36	61.44	47.76
English hay, .	Young Sheep I., .	55.98	42.98	48.09	56.09	59.91	49.46
	Young Sheep II.,	59.03	43.77	47.36	61.21	62.65	52.80
	Young Sheep III.,	56.21	44.17	46.65	55.35	60.78	52.86
	Average, . .	57.07	43.64	47.37	57.55	61.11	51.71
English hay, .	Old Sheep II., .	61.72	47.36	55.54	64.52	64.01	50.45
	Old Sheep III., .	59.74	43.67	51.87	63.09	62.18	50.08
	Average, . .	60.73	45.52	53.71	63.81	63.10	50.27

Discussion of the Results.

The most important results obtained from the experiments reported in the previous pages are discussed under the following headings: —

Soy Bean Fodder (Brook's Medium Green). — This fodder was grown upon a twentieth-acre plat which had produced soy beans for two years previously. The crop was fertilized in the same way as that used in a digestion trial the previous year, and yielded at the rate of 6 tons to the acre. The fodder was cut from time to time as needed during the first fourteen days of September, the period proper lasting from the 8th to the 14th. The plants were fully podded and the beans quite well developed, but the foliage was still green. In common with other legumes at a similar stage of growth, the soy bean fodder showed a high protein percentage, and moderate percentages of fiber and extract matter.

Summary of Digestion Coefficients (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	-	1	68.77	45.20	81.30	53.37	78.47	69.31
Young Sheep II.,	-	1	64.09	38.95	79.61	46.63	73.91	65.38
Young Sheep III.,	-	1	61.61	33.72	79.88	42.65	71.44	67.80
Average (1904),	1	3	64.82	39.29	80.26	47.55	74.61	67.50
Average (1903),	1	3	63.53	21.05	82.96	38.90	77.82	65.42
Average, both trials,	2	6	64.17	30.17	81.61	43.42	76.22	66.46
Average, all trials seeding,	4	12	65.00	28.00	78.00	45.00	77.00	55.00
Clover for comparison,	3	7	66.00	-	70.00	54.00	72.00	64.00
Cowpea fodder for comparison,	2	4	68.00	23.00	76.00	60.00	81.00	59.00

The 1904 trial was made with one lot of sheep, and the 1903 trial with another. The results of both trials agree as closely as could be expected. The soy bean fodder appears to be slightly less digestible than that of other legumes, due in all probability to the tough, woody stems which are characteristic of the plant. Note the low digestibility of the fiber and the high digestibility of the protein.

Blomo Feed. — This feed, put out by the Blomo Manufacturing Company of New York, consisted of a fibrous material resembling ground corn stalks or cut hay, together with fresh blood and molasses. It was quite dark in color, coarse in appearance and rather sticky to the touch. Many samples contained an excess of moisture, which caused it to spoil during the warm season. The sample under examination contained, in dry matter, some 17 per cent. protein, 13 per cent. fiber and only a trace of fat.

Summary of Digestion Coefficients (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	64.02	31.20	64.48	50.81	73.20	13.79
Old Sheep III.,	1	1	69.46	31.62	60.98	71.89	78.70	16.75
Average,	1	2	66.74	31.41	62.73	61.35	75.95	15.27
Oats for comparison,	3	13	71.00	–	80.00	30.00	76.00	83.00
Rowen for comparison,	4	16	64.00	–	69.00	66.00	64.00	47.00

The parallel tests do not agree quite as closely as one could wish, the cause of the disagreement being due primarily to the fact that Sheep II. was not able to digest the fiber as fully as Sheep III. The percentage of fat is so small (less than 1 per cent.) that its digestibility is of minor consequence. It is understood that the Blomo feed was intended to be used chiefly as an oat substitute for horses. A comparison of the digestion coefficients of the two feeds proves the Blomo to be not quite as fully digested as the oats. The advantages, therefore, if any, of the Blomo feed would be due to the favorable effect of the molasses, and in its furnishing a change from the regular corn and oat diet. At the price asked Blomo could not be considered an economical feed for dairy stock. Its digestion coefficients do not vary greatly from those of a good quality of rowen, and it is doubtful if it would produce any more favorable results.

Malt Sprouts. — The sprouts were of good color, and contained nearly 29 per cent. of crude protein, 33.47 per cent. of which was in the amido form.

Summary of Digestion Coefficients (Per Cent.).

Period III.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	89.03	33.30	77.23	100+	91.35	85.38
Young Sheep II.,	1	1	75.13[1]	2.87	73.87	100.00	77.56	74.42
Young Sheep III.,	1	1	81.45	21.18	76.67	98.26	86.99	100.00
Average,	1	3	81.87	19.12	75.92	99.42	85.30	86.60
Average, all trials, made in Massachusetts.	2	4	81.00	19.00	76.00	100.00	83.00	80.00
German trials,[2]	6	12	72.00[3]	–	80.00	55.00	73.00	71.00

The results with the three sheep show wide variations, especially in case of the total dry matter, ash and extract matter, and it is evident that difficulty was experienced in digesting the sprouts. Similar results were experienced in a previous trial,[4] two sheep digesting but 60 per cent. of the dry matter and a third 78 per cent. The results secured with the two former sheep were discarded. The high fiber coefficients in the present experiment indicate that the addition of the nitrogenous sprouts increased the digestibility of the hay fiber.

The results of German experiments likewise show especially wide variations in the digestibility of the organic matter, fiber and extract matter. The latter experiments do not show as high an average digestibility for fiber as do our own trials. It seems probable that these differences may be due largely to the character of the sprouts employed. Böhmer[5] states that light-colored sprouts show a higher degree of digestibility than dark-brown sprouts derived from slightly scorched malt. Kellner[6] has shown that, while the organic matter of the sprouts has a reasonably high digestibility because of the presence of considerable quantities of amids, cane sugar and organic acids, a definite amount does

[1] The fæces from Sheep II. were somewhat soft for a few days during the collection, which was an evidence of indigestion.

[2] Kellner's Die Ernährung der Landw. Nutzthiere, page 570.

[3] Organic matter.

[4] See sixteenth report of this station, page 77.

[5] Kraftfuttermittel, page 206.

[6] *Loco citato*, pages 160, 357.

not have as great a feeding effect as does a like amount contained in the cereals.

Sucrene Dairy Feed. — This is one of the so-called sugar feeds, consisting of wheat, corn, oats and barley products (or by-products), light oats, cotton-seed meal or other protein concentrate, and one-fourth to one-third molasses. The sample tested contained (in dry matter) 18.48 per cent. protein and 14.11 per cent. fiber.

Summary of Digestion Coefficients (Per Cent.).

Period IX.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	71.58	47.51	64.45	70.41	74.57	96.06
Old Sheep III.,	1	1	67.38	27.92	57.12	73.46	70.50	92.75
Average,	1	2	69.48	37.72	60.79	71.94	72.54	94.41
Wheat bran for comparison,	8	18	62.00	-	77.00	21.00	69.00	66.00
Flour middlings for comparison.	1	2	83.00	-	85.00	36.00	88.00	85.00
Gluten feed for comparison,	5	11	85.00	-	85.00	76.00	89.00	83.00

The sugar feed may be said to be but moderately digestible. In total dry matter it is rather more digestible than bran, but the protein in the latter has noticeably higher digestion coefficients. It is decidedly less digestible than either flour middlings or gluten feed, and either of the two latter feeds would furnish digestible matter and especially digestible protein for less money than the Sucrene feed.

Holstein Sugar Feed. — This feed appeared to be a mixture of cereal products or by-products, molasses and some cotton-seed meal. It contained rather less water than the Sucrene, but was coarser and rather more sticky to handle.

Summary of Digestion Coefficients (Per Cent.).

Period X.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., ...	1	1	70.16	24.08	61.22	44.28	80.61	88.49
Young Sheep II., ...	1	1	74.13	31.74	64.90	62.30	82.04	88.61
Young Sheep III., ...	1	1	69.63	43.08	70.83	25.64	78.85	86.39
Average, ...	1	3	71.31	32.97	65.65	44.07	80.50	87.83

The dry matter of the Holstein feed was about as digestible as that contained in the Sucrene feed. Its fiber was rather less digestible and its extract matter had a higher digestibility than that contained in the latter feed.

Macon Sugar Feed. — This feed was furnished by Chapin & Co., and shipped from St. Louis. In appearance it quite closely resembled the Sucrene feed. The sample contained rather less protein and fiber and noticeably more extract matter than the Sucrene.

Summary of Digestion Coefficients (Per Cent.).

Period XI.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	69.03	20.52	60.50	36.40	80.83	74.07
Old Sheep III., ...	1	1	72.03	20.31	57.26	51.35	83.41	90.66
Average, ...	1	2	70.53	20.42	58.88	43.88	82.12	82.37

The results secured with the Macon feed do not vary materially from those obtained with the Sucrene and Holstein feeds. The fiber in the Macon is rather less and the extract matter more digestible than that contained in the Sucrene. In general it may be said that the digestibility of the three sugar feeds resembles each other quite closely.[1]

[1] The economic value of these feeds will be more fully discussed in a future bulletin on the value of molasses and molasses feeds.

Eureka Silage Corn Stover. — This was derived from Eureka corn [1] grown on an experiment plat of the station during 1904, and cured in the stock out of doors. The corn was cut September 15, the ears at the time being only partially developed (kernels forming). The digestion experiment was made with the entire plant, minus the ears. In spite of the fact that the corn was well cured, it contained 62.89 per cent. water.

Pride of the North Corn Stover. — This corn was grown the same season, on a plat near by the Eureka, and received the same treatment. It was fairly well eared. The digestion test was made with the entire plant, minus the ears.

Summary of Digestion Coefficients (Per Cent.).

Periods V and VII.

		Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Eureka.	Old Sheep II.,	1	1	53.53	46.13	49.67	56.18	52.86	66.18
	Old Sheep III.,	1	1	55.27	43.88	46.91	61.94	52.99	66.98
	Average,	1	2	54.40	45.01	48.29	59.06	52.93	66.58
Pride of the North.	Old Sheep II.,	1	1	52.87	32.82	44.57	57.89	53.08	63.05
	Old Sheep III.,	1	1	55.06	29.36	45.12	62.60	54.68	65.75
	Average,	1	2	53.97	31.09	44.85	60.25	53.88	64.40
Average, all trials, for corn stover.		11	31	57.00	41.00	36.00	64.00	59.00	70.00

Both varieties of corn stover were equally well digested. The digestion coefficients are slightly lower than the average results of all trials.

English Hay. — This hay consisted largely of Kentucky blue grass (*Poa pratensis*), with an admixture of timothy, sweet vernal grass and red clover. It was cut June 20, when the blue grass and clover were in blossom, and carefully cured. The hay was used in connection with the several experiments reported in this series.

[1] See eighteenth report of this station, pages 86–93.

Summary of Coefficients (Per Cent.).

Periods.		Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
VI.,	Paige Sheep IV., .	1	1	57.54	36.96	50.89	59.76	60.88	50.81
	Paige Sheep V., .	1	1	58.41	44.07	56.33	58.36	61.94	44.70
	Average, . .	1	2	57.98	40.52	53.61	59.06	61.44	47.76
IX.,	Old Sheep II., . .	1	1	61.72	47.36	55.54	64.52	64.01	50.45
	Old Sheep III., . .	1	1	59.74	43.67	51.87	63.09	62.18	50.08
	Average, . .	1	2	60.72	45.50	53.69	63.79	63.08	50.24
VIII.,	Young Sheep I., .	1	1	55.98	42.98	48.09	56.09	59.91	49.46
	Young Sheep II., .	1	1	59.03	43.77	47.36	61.21	62.65	52.80
	Young Sheep III., .	1	1	56.21	44.17	46.65	55.35	60.78	52.86
	Average, . .	1	3	57.07	43.64	47.37	57.55	61.11	51.71
	Average, all sheep, .	1	7	58.38	43.28	50.96	59.76	61.77	50.16
	Average, all previous trials.	15	60	60.00	47.00	57.00	60.00	61.00	50.00
	Average, timothy hay.	24	58	55.00	39.00	48.00	50.00	62.00	50.00

The so-called "Old Sheep" gave slightly higher coefficients than the other two lots. The former are some six years and the latter four years old. This difference in ability to digest, especially between the old and young sheep, has been noticed repeatedly. The hay gave about the same digestion coefficients as those secured with similar lots in previous trials. Hay of this character, designated "cow hay" by farmers, tests higher in protein, is rather more digestible, and probably requires less energy for its digestion than timothy hay.

Hominy Feed. — This material consisted of the hull, germ and some of the gluten and starch of the Indian corn. The sample appeared to be of good average quality.

Summary of Digestion Coefficients (Per Cent.).

Period XII.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	89.26	37.38	67.23	97.43	94.42	88.62
Paige Sheep V., ...	1	1	85.90	60.37	71.85	62.49	90.79	87.70
Average, ...	1	2	87.58	48.88	69.54	79.96	92.61	88.16
Average, 1903,[1]	1	3	80.75	22.74	67.48	–	85.97	91.61
Average, 1904,[1]	1	3	79.42	38.26	58.07	38.12	87.66	94.09
Average, all trials, . . .	3	8	81.96	35.10	64.47	79.96	88.26	91.68
Corn meal for comparison, .	–	–	89.00	–	70.00	–	94.00	91.00

[1] Seventeenth report of this station, page 75.

The results of the two trials in the present experiment agree fairly well one with the other, and the average of the two are nearly equal to the coefficients for corn meal. The coefficients secured with the several sheep in the two previous experiments (1903 and 1904) showed marked differences. While these variations may have been due partially to the quality of the two different lots of hominy (which, however, could not be detected by chemical analysis), it seems probable that the chief cause for the lack of agreement is to be found in the sheep themselves. The writer has frequently noticed that after sheep have been used in digestion work for a number of months their power to digest becomes temporarily weakened. This condition is more noticeable with some sheep than with others, and evidently depends largely upon individuality. The digestion coefficients for hominy secured with the Old Sheep (1903) were obtained in one of a series of experiments extending from the autumn of 1902 to March 1903. The hominy meal period was the last of the series, and the digestibility of the dry matter varied from 71 to 91 per cent. The coefficients reported with the Young Sheep (1904) (75 to 86 per cent. of dry matter digestible) were obtained in a series extending from the autumn of 1903 to the spring of 1904. These sheep were used for the first time in this series, and were alternated to an extent with the Old

Sheep. The hominy feed was used in the last of four experiments made with these sheep during the series. While the latter results agree better than those secured with the Old Sheep, they were not as satisfactory as could be desired.

The average of all trials show the dry matter to be 82 per cent. digestible. It is believed, however, that the coefficients secured with the Paige Sheep (fully reported in the present trial) more closely represent the digestibility of the best grades of hominy feed. Allowing hominy feed to contain 91 per cent. and corn meal 86 per cent. of dry matter, and applying the average digestion coefficients secured for hominy and corn meal, the former would contain 1,492 pounds and the latter 1,541 pounds digestible dry matter in one ton. By using the coefficients secured with the Paige Sheep, the hominy is shown to contain 1,565 pounds of digestible dry matter in a ton. It may therefore safely be assumed that a ton of standard hominy feed has fully as much digestible matter as is contained in a like quantity of an average quality of corn meal. Hominy contains rather more protein and noticeably more fat than clear corn, and for some purposes may be considered a preferable feed.

Oat Middlings, occasionally found upon the market, is presumably the fine residue from the oatmeal factories. It contains but a few per cent. of fiber, about 9 per cent. of water, 16 per cent. of protein and 6 per cent. of fat.

Summary of Digestion Coefficients (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep I.,	1	1	91.27	31.28	81.18	76.54	96.58	92.81
Paige Sheep II.,	1	1	88.02	39.83	79.53	21.32	93.95	93.63
Average,	1	2	89.65	35.56	80.36	48.93	95.27	93.22
Average fine wheat middlings for comparison.	2	4	82.00	–	88.00	36.00	88.00	86.00

The oat middlings are shown to be quite thoroughly digested, especially the starchy matter and fat; the protein had also a relatively high digestibility. The small amount of

fiber present renders its degree of digestibility comparatively unimportant. Judged from composition and digestibility, this oat by-product would be a few per cent. more valuable than average wheat flour middlings for ordinary feeding purposes. It ought to make a valuable feed for young calves.

Buckwheat Middlings. — This material is the residue from small mills which prepare buckwheat flour for human use. It consisted of the middlings and a small portion of the bran. Genuine buckwheat middlings should contain 25 per cent. of protein, 7 per cent. of fat and not over 10 per cent. of fiber. Samples found in the market known as buckwheat feed frequently show a considerable admixture of the bran and analyze as high as 25 per cent. of fiber. Buckwheat bran is very indigestible, and consequently such material is quite inferior in feeding value to the straight middlings.

Summary of Digestion Coefficients (Per Cent.).

Period XIII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., ...	1	1	75.14	25.80	86.04	7.74	83.56	88.31
Young Sheep II., ...	1	1	78.72	41.35	83.03	26.11	87.00	92.30
Young Sheep III., ...	1	1	71.27	39.52	86.31	–	79.24	87.47
Average, ...	1	3	75.04	35.56	85.13	16.92[1]	83.27	89.36
Gluten feed for comparison, .	7	13	86.00	–	85.00	76.00	89.00	83.00

Sheep III. did not digest the middlings quite as well as the other two sheep. The material, as is shown by the coefficients obtained for the dry matter, appeared to be fairly well digested, although not as fully as the easily digested gluten feed. The protein had a high digestibility, being equal to other high-grade protein concentrates. It is evident from the analysis, from the digestion coefficients obtained and from the retail price of the article ($26 to $28 a ton) that genuine buckwheat middlings is an economical source of dry matter and digestible protein.[1]

[1] Average, two trials.

[2] It is not advisable to feed over 3 pounds of this material daily to mature dairy stock; larger quantities are likely to cause illness.

Series XI.

This series was begun August 12, 1905, with Early Amber Sorghum, and continued until April 7, 1906. The Paige Sheep worked especially well in this series, and were used in the larger number of the experiments. The digestion hay used in periods III. and IV. was the new hay described in the previous series, to which the reader is referred for composition and digestion coefficients. The composition of the hay used in all other periods is given in the table of analyses. The coefficients employed were the following: —

	Old Sheep II. and III.	Young Sheep I., II. and III.	Paige Sheep IV. and V.
Dry matter,	67.87	65.92	65.48
Ash,	49.17	51.95	44.60
Protein,	62.31	61.98	61.53
Fiber,	76.30	72.87	73.81
Nitrogen-free extract,	66.39	64.66	64.46
Fat,	52.37	54.23	50.20

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
English hay (used in 1904–05 experiments),	8.20	8.69	32.14	48.56	2.41
Early Amber Sorghum fodder,	6.06	6.24	29.28	56.00	2.42
Pride of the North corn fodder,	5.56	8.83	23.11	60.24	2.26
Porto Rico molasses,	8.45	3.94	–	87.61	–
English hay (new lot, 1905–06),	6.75	12.23	33.45	44.67	2.90
Gluten feed,	1.67	24.98	7.22	63.34	2.79
Porto Rico molasses,	9.22	3.94	–	86.84	–
Green Diamond sugar feed,	9.88	13.71	15.27	58.47	2.67
Sea Island cotton-seed meal,	5.20	27.31	19.67	41.47	6.35
Red wheat meal,	1.92	9.96	2.99	82.83	2.80
Leaming corn silage,	6.07	10.19	26.06	54.89	2.79
White winter wheat meal,	1.90	13.07	2.38	80.49	2.16
Feed barley (ground),	3.27	14.60	6.19	73.90	2.04

Composition of Fæces (Per Cent.).

[Dry Matter.]

Periods.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
	Young Sheep I.					
IX.,	English hay (1905–06),	9.82	13.27	26.90	46.01	4.00
XII.,	Red wheat meal,	9.91	15.66	24.82	45.61	4.00
XV.,	White winter wheat,	10.39	14.70	24.51	46.02	4.38
	Young Sheep II.					
IX.,	English hay (1905–06),	9.68	14.55	25.28	46.62	3.87
XV.,	White winter wheat,	11.60	15.20	24.26	45.16	3.78
	Young Sheep III.					
IX.,	English hay (1905–06),	9.07	13.14	27.65	46.32	3.82
XII.,	Red wheat meal,	9.24	15.08	25.85	46.02	3.81
XV.,	White winter wheat,	9.15	14.24	26.30	46.23	4.08
	Old Sheep II.					
II.,	Pride of the North corn fodder,	11.86	11.17	27.55	47.68	1.74
VI.,	English hay (1905–06),	10.80	14.70	23.99	46.27	4.24
XIII.,	Leaming corn silage,	10.48	13.70	25.15	47.75	2.92
	Old Sheep III.					
II.,	Pride of the North corn fodder,	12.86	11.18	27.68	46.35	1.93
VI.,	English hay (1905–06),	10.57	14.03	25.31	45.74	4.35
X.,	Green Diamond sugar feed,	14.70	13.68	24.47	44.42	2.73
XIII.,	Leaming corn silage,	10.39	13.02	25.14	48.47	2.98
	Paige Sheep IV.					
I.,	Early Amber Sorghum,	11.28	11.13	27.02	47.44	3.13
III.,	Porto Rico molasses,	12.16	10.72	29.32	44.87	2.93
IV.,	Porto Rico molasses,	13.66	11.47	27.13	44.86	2.88
V.,	English hay (1905–06),	11.18	14.10	24.20	46.24	4.28
VII.,	Gluten feed,	10.55	15.33	22.35	47.20	4.57
VIII.,	Gluten feed and molasses,	11.15	16.36	21.26	47.44	3.79
XI.,	Sea Island cotton-seed meal,	8.67	14.17	32.75	41.31	3.10
XIV.,	Green Diamond sugar feed,	13.02	12.79	25.41	45.59	3.19
XVI.,	Feed barley,	12.50	13.86	23.08	46.46	4.10

Composition of Fæces — Concluded.

[Dry Matter.]

Paige Sheep V.

Periods.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
I.,	Early Amber Sorghum, ...	11.06	9.39	31.21	45.75	2.59
III.,	Porto Rico molasses, ...	11.83	10.53	30.33	44.47	2.84
IV.,	Porto Rico molasses, ...	12.87	11.49	28.95	43.94	2.75
V.,	English hay (1905–06), . . .	10.49	13.17	26.51	45.74	4.09
VII.,	Gluten feed, ...	10.63	15.05	22.84	46.84	4.64
VIII.,	Gluten feed and molasses, . . .	10.82	16.21	22.09	47.15	3.73
XI.,	Sea Island cotton-seed meal, . .	9.33	15.20	29.46	42.86	3.15
XVI.,	Feed barley, ...	11.14	13.86	25.39	45.75	3.86

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Paige Sheep IV.

Periods.	English Hay.	Early Amber Sorghum.	Porto Rico Molasses.	Gluten Feed.	Sea Island Cotton-seed Meal.	Green Diamond Sugar Feed.	Feed Barley.	Fæces.
I.,	-	16.35	-	-	-	-	-	87.84
III.,	88.15	-	71.49	-	-	-	-	92.84
IV.,	87.22	-	72.12	-	-	-	-	92.33
V.,	88.65	-	-	-	-	-	-	92.22
VII.,	88.55	-	-	90.03	-	-	-	93.47
VIII.,	88.92	-	72.67	92.02	-	-	-	92.50
XI.,	90.92	-	-	-	90.97	-	-	93.16
XIV.,	90.17	-	-	-	-	89.62	-	94.42
XVI.,	89.35	-	-	-	-	-	89.07	92.96

Paige Sheep V.

Periods.	English Hay.	Early Amber Sorghum.	Porto Rico Molasses.	Gluten Feed.	Sea Island Cotton-seed Meal.	Green Diamond Sugar Feed.	Feed Barley.	Fæces.
I.,	-	16.35	-	-	-	-	-	87.69
III.,	88.15	-	71.49	-	-	-	-	93.14
IV.,	87.22	-	72.12	-	-	-	-	92.16
V.,	88.65	-	-	-	-	-	-	92.14
VII.,	88.55	-	-	90.03	-	-	-	93.61
VIII.,	88.92	-	72.67	92.02	-	-	-	92.36
XI.,	90.92	-	-	-	90.97	-	-	92.98
XVI.,	89.35	-	-	-	-	-	89.07	92.80

Dry Matter Determinations, etc. — Concluded..

Young Sheep I.

Periods.	English Hay.	Pride of the North Corn Fodder.	Green Diamond Sugar Feed.	Red Wheat Meal.	Leaming Corn Silage.	White Wheat Meal.	Fæces.
IX., ...	90.35	–	–	–	–	–	94.99
XII., ...	88.92	–	–	87.43	–	–	94.25
XV., ...	89.60	–	–	–	–	87.80	93.27
Young Sheep II.							
IX., ...	90.35	–	–	–	–	–	94.72
XV., ...	89.60	–	–	–	–	87.80	92.91
Young Sheep III.							
IX., ...	90.35	–	–	–	–	–	94.86
XII., ...	88.92	–	–	87.43	–	–	94.17
XV., ...	89.60	–	–	–	–	87.80	93.09
Old Sheep II.							
II., ...	–	22.61	–	–	–	–	89.28
VI., ...	88.97	–	–	–	–	–	93.54
XIII., ...	90.17	–	–	–	21.44	–	94.12
Old Sheep III.							
II., ...	–	22.61	–	–	–	–	89.09
VI., ...	88.97	–	–	–	–	–	93.52
X., ...	88.95	–	91.95	–	–	–	94.09
XIII., ...	90.17	–	–	–	21.44	–	94.19

Average Daily Amount of Manure excreted and Water drank (*Grams*).

Paige Sheep IV.

Periods.	Character of Food or Ration.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
I.,	Early Amber Sorghum, ...	500	41.06[1]	49
III.,	Hay and Porto Rico molasses, ...	674	31.10	1,725
IV.,	Hay and Porto Rico molasses, ...	738	33.34	2,114
V.,	English hay, ...	610	26.11	1,781
VII.,	Hay and gluten feed, ...	460	20.82	1,498
VIII.,	Hay, gluten feed and molasses, . . .	635	25.84	1,843
XI.,	Hay and Sea Island cotton-seed meal, . .	607	29.67	2,095
XIV.,	Hay and Green Diamond sugar feed, . .	598	27.45	2,241
XVI.,	Hay and feed barley, ...	478	20.32	1,644

[1] One-fifth of daily amount excreted.

Average Daily Amount of Manure excreted and Water drank (Grams) — Concluded.

Paige Sheep V.

Periods.	Character of Food or Ration.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
I.,	Early Amber Sorghum,	591	43.80[1]	55
III.,	Hay and Porto Rico molasses,	745	32.86	1,995
IV.,	Hay and Porto Rico molasses,	855	34.12	2,014
V.,	English hay,	623	27.02	1,642
VII.,	Hay and gluten feed,	459	20.01	1,318
VIII.,	Hay, gluten feed and molasses,	655	25.86	1,953
XI.,	Hay and Sea Island cotton-seed meal,	673	26.70	2,138
XIV.,	Hay and Green Diamond sugar feed,	–	–	–
XVI.,	Hay and feed barley,	705	21.50	1,644

[1] One-fifth of daily amount excreted.

Young Sheep I.

IX.,	English hay (new lot),	635	27.46	2,170
XII.,	Hay and red wheat meal,	557	20.98	2,025
XV.,	Hay and white winter wheat,	488	21.86	2,038

Young Sheep II.

IX.,	English hay (new lot),	779	26.96	2,341
XII.,	Hay and red wheat meal,	–	–	–
XV.,	Hay and white winter wheat,	1,077	24.15	2,338

Young Sheep III.

IX.,	English hay (new lot),	695	28.35	2,495
XII.,	Hay and red wheat meal,	617	22.32	2,352
XV.,	Hay and white winter wheat,	537	22.99	2,495

Old Sheep II.

II.,	Pride of the North corn fodder,	624	25.62	80
VI.,	English hay (1905–06),	613	26.21	1,694
X.,	Hay and Green Diamond sugar feed,	–	–	–
XIII.,	Hay and Leaming corn silage,	747	24.04	1,974

Old Sheep III.

II.,	Pride of the North corn fodder,	820	28.12	60
VI.,	English hay (1905–06),	608	28.80	1,544
X.,	Hay and Green Diamond sugar feed,	676	27.08	2,329
XIII.,	Hay and Leaming corn silage,	537	22.42	1,309

Weights of Animals at Beginning and End of Period (Pounds).

Paige Sheep IV.

Periods.	Character of Food or Ration.	Beginning.	End.
I.,	Early Amber Sorghum,	147.00	146.50
III.,	Hay and Porto Rico molasses,	144.00	142.00
IV.,	Hay and Porto Rico molasses,	145.50	150.00
V.,	English hay,	142.00	144.00
VII.,	Hay and gluten feed,	141.50	141.00
VIII.,	Hay, gluten feed and molasses,	145.00	142.00
XI.,	Hay and Sea Island cotton-seed meal,	144.00	145.00
XIV.,	Hay and Green Diamond sugar feed,	145.50	148.50
XVI.,	Hay and feed barley,	148.00	143.50

Paige Sheep V.

Periods.	Character of Food or Ration.	Beginning.	End.
I.,	Early Amber Sorghum,	124.25	126.00
III.,	Hay and Porto Rico molasses,	124.00	122.00
IV.,	Hay and Porto Rico molasses,	122.50	125.50
V.,	English hay,	122.00	121.50
VII.,	Hay and gluten feed,	118.50	120.00
VIII.,	Hay, gluten feed and molasses,	125.50	122.50
XI.,	Hay and Sea Island cotton-seed meal,	124.50	123.50
XIV.,	Hay and Green Diamond sugar feed,	-	-
XVI.,	Hay and feed barley,	124.50	117.00

Young Sheep I.

Periods.	Character of Food or Ration.	Beginning.	End.
IX.,	English hay (1905–06),	121.00	119.00
XII.,	Hay and red wheat meal,	118.00	117.00
XV.,	Hay and white winter wheat,	119.50	118.00

Young Sheep II.

Periods.	Character of Food or Ration.	Beginning.	End.
IX.,	English hay (1905–06),	111.00	113.00
XII.,	Hay and red wheat meal,	-	-
XV.,	Hay and white winter wheat,	-	-

Young Sheep III.

Periods.	Character of Food or Ration.	Beginning.	End.
IX.,	English hay (1905–06),	113.00	110.00
XII.,	Hay and red wheat meal,	109.00	109.00
XV.,	Hay and white winter wheat,	110.00	108.50

Weights of Animals at Beginning and End of Period (Pounds) — Concluded.

Old Sheep II.

Periods.	Character of Food or Ration.	Beginning.	End.
II.,	Pride of the North corn fodder,	160.00	154.00
VI.,	English hay (1905-06),	154.00	150.00
X.,	Hay and Green Diamond sugar feed,	-	-
XIII.,	Hay and Leaming corn silage,	154.50	155.00

Old Sheep III.

II.,	Pride of the North corn fodder,	151.50	150.00
VI.,	English hay (1905-06),	146.50	145.00
X.,	Hay and Green Diamond sugar feed,	145.00	147.50
XIII.,	Hay and Leaming corn silage,	152.00	152.00

Early Amber Sorghum. — Period I.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Sorghum fodder fed,	588.60	35.67	36.73	172.34	329.62	14.24
205.30 grams manure excreted,	180.34	20.34	20.07	48.73	85.55	5.64
Grams digested,	408.26	15.33	16.66	123.61	244.07	8.60
Per cent. digested,	69.36	42.98	45.36	71.72	74.04	60.39

Paige Sheep V.

3,600 grams Sorghum fodder fed,	588.60	35.67	36.73	172.34	329.62	14.24
219 grams manure excreted,	192.04	21.24	18.03	59.94	87.86	4.97
Grams digested,	396.56	14.43	18.70	112.40	241.76	9.27
Per cent. digested,	67.37	40.45	50.91	65.22	73.35	65.10
Average per cent. for both sheep,	68.37	41.72	48.14	68.47	73.70	62.75

Average nutritive ratio of rations for two sheep, 1:21.5.

Pride of the North Corn Fodder. — Period II.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Pride of the North corn fodder fed.	813.96	45.26	71.87	188.11	490.33	18.40
256.23 grams manure excreted, . .	228.76	27.13	25.55	63.02	109.07	3.98
Grams digested, ...	585.20	18.13	46.32	125.09	381.26	14.42
Per cent. digested, ...	71.89	40.06	64.45	66.50	77.76	78.37

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Pride of the North corn fodder fed.	813.96	45.26	71.87	188.11	490.33	18.40
281.19 grams manure excreted, . .	250.51	32.22	28.01	69.34	116.11	4.83
Grams digested, ...	563.45	13.04	43.86	118.77	374.22	13.57
Per cent. digested, ...	69.22	28.81	61.03	63.14	76.32	73.75
Average per cent. for both sheep, .	70.56	34.43	62.74	64.82	77.04	76.06

Average nutritive ratio of rations for two sheep, 1:11.8.

Porto Rico Molasses. — Period III.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, ...	705.20	57.83	61.28	226.65	342.45	17.00
150 grams molasses fed, ...	107.24	9.06	4.23	–	93.95	–
Amount consumed, ...	812.44	66.89	65.51	226.65	436.40	17.00
311 grams manure excreted, . . .	288.73	35.11	30.95	84.66	129.55	8.46
Grams digested, ...	523.71	31.78	34.56	141.89	306.85	8.54
Minus hay digested, ...	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested, ...	114.84	8.35	1.71	8.03	96.55	.42
Per cent. digested, ...	107.09	92.16	40.43	–	102.76	–

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	812.44	66.89	65.51	226.65	436.40	17.00
328.60 grams manure excreted, . .	306.06	36.21	32.23	92.83	136.10	8.69
Grams digested, ...	506.38	30.68	33.28	133.82	300.30	8.31
Minus hay digested, ...	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested, ...	97.51	7.25	.43	–	90.00	.19
Per cent. digested, ...	90.93	80.02	10.17	–	95.80	–
Average per cent. for both sheep, .	99.01	86.09	25.30	–	99.28	–

Average nutritive ratio of rations for two sheep, 1:13.6.

Porto Rico Molasses. — Period IV.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	697.76	57.22	60.64	224.26	338.82	16.82
250 grams molasses fed,	180.30	15.24	7.10	–	157.96	–
Amount consumed,	878.06	72.46	67.74	224.26	496.78	16.82
333.40 grams manure excreted,	307.83	42.05	35.31	83.51	138.09	8.87
Grams digested,	570.23	30.41	32.43	140.75	358.69	7.95
Minus hay digested,	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested,	165.67	7.22	—.08	8.31	150.62	–
Per cent. digested,	91.89	47.38	–	–	95.35	–

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	878.06	72.46	67.74	224.26	496.78	16.82
341.2 grams manure excreted,	314.45	40.47	36.13	91.03	138.17	8.65
Grams digested,	563.61	31.99	31.61	133.23	358.61	8.17
Minus hay digested,	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested,	159.05	8.80	.10	.79	150.54	.14
Per cent. digested,	88.21	57.74	–	–	95.30	–
Average per cent. for both sheep,	90.05	52.56	–	–	95.33	–

Average nutritive ratio of rations for two sheep, 1:16.

English Hay. — Period V.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
261.10 grams manure excreted,	240.79	26.92	33.95	58.27	111.34	10.31
Grams digested,	468.41	20.95	52.79	178.96	205.46	10.26
Per cent. digested,	66.05	43.76	60.86	75.44	64.85	49.88

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	709.20	47.87	86.74	237.23	316.80	20.57
270.20 grams manure excreted,	248.96	26.12	32.79	66.00	113.87	10.18
Grams digested,	460.24	21.75	53.95	171.23	202.93	10.39
Per cent. digested,	64.90	45.44	62.20	72.18	64.06	50.51
Average per cent. for both sheep,	65.48	44.60	61.53	73.81	64.46	50.20

Average nutritive ratio of rations for two sheep, 1: 7.5.

English Hay. — Period VI.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
262.10 grams manure excreted,	245.17	26.48	36.04	58.82	113.44	10.40
Grams digested,	555.56	27.57	61.89	209.02	244.25	12.82
Per cent. digested,	69.38	51.01	63.20	78.04	68.29	55.21
Old Sheep III.						
900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
288 grams manure excreted,	269.34	28.47	37.79	68.17	123.20	11.72
Grams digested,	531.39	25.58	60.14	199.67	234.49	11.50
Per cent. digested,	66.36	47.33	61.41	74.55	65.56	49.53
Average per cent. for both sheep,	67.87	49.17	62.31	76.30	66.39	52.37

Average nutritive ratio of rations for two sheep, 1: 7.7.

Gluten Feed. — Period VII.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	531.30	35.86	64.98	177.72	237.33	15.41
200 grams gluten feed fed,	180.06	3.01	44.98	13.00	114.05	5.02
Amount consumed,	711.36	38.87	109.96	190.72	351.38	20.43
208.20 grams manure excreted,	194.60	20.53	29.83	43.49	91.85	8.89
Grams digested,	516.76	18.34	80.13	147.23	259.53	11.54
Minus hay digested,	347.90	15.99	39.98	131.18	152.98	7.74
Gluten feed digested,	168.86	2.35	40.15	16.05	106.55	3.80
Per cent. digested,	93.78	78.07	89.26	123.46	93.42	75.70
Paige Sheep V.						
Amount consumed as above,	711.36	38.87	109.96	190.72	351.38	20.43
200.10 grams manure excreted,	187.31	19.91	28.19	42.78	87.74	8.69
Grams digested,	524.05	18.96	81.77	147.94	263.64	11.74
Minus hay digested,	347.90	15.99	39.98	131.18	152.98	7.74
Gluten feed digested,	176.15	2.97	41.79	16.76	110.66	4.00
Per cent. digested,	97.83	98.67	92.91	128.92	97.03	79.68
Average per cent. for both sheep,	95.81	88.37	91.09	126.19	95.23	77.69

Average nutritive ratio of rations for two sheep, 1: 5.4.

Porto Rico Molasses. — Period VIII.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	533.52	36.01	65.25	178.46	238.32	15.47
200 grams gluten feed fed,	184.04	3.07	45.97	13.29	116.57	5.13
250 grams molasses fed,	181.68	16.75	7.16	–	157.77	–
Amount consumed,	899.24	55.83	118.38	191.75	512.66	20.60
258.40 grams manure excreted,	239.02	26.65	39.10	50.82	113.39	9.06
Grams digested,	660.22	29.18	79.28	140.93	399.27	11.54
Minus hay and gluten feed digested,	521.24	18.44	81.05	–	262.12	–
Molasses digested,	138.98	10.74	–	–	137.15	–
Per cent. digested,	76.50	64.12	–	–	86.93	–

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	899.24	55.83	118.38	191.75	512.66	20.60
258.60 grams manure excreted,	238.84	25.84	38.72	52.76	112.61	8.91
Grams digested,	660.40	29.99	79.66	138.99	400.05	11.69
Minus hay and gluten feed digested,	528.63	19.06	82.70	–	266.27	–
Molasses digested,	131.77	10.93	–	–	133.78	–
Per cent. digested,	72.53	65.25	–	–	84.80	–
Average per cent. for both sheep,	74.52	64.69	–	–	85.87	–

Average nutritive ratio of rations for two sheep, 1: 7.1.

English Hay. — Period IX.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay fed,	767.98	51.84	93.92	256.89	342.96	22.27
274.60 grams manure excreted,	260.84	25.61	34.61	70.17	120.01	10.43
Grams digested,	507.14	26.23	59.31	186.72	222.95	11.84
Per cent. digested,	66.04	50.60	63.15	72.68	65.01	53.17

Young Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay fed,	767.98	51.84	93.92	256.89	342.96	22.27
269.60 grams manure excreted,	255.37	24.72	37.16	64.56	119.05	9.88
Grams digested,	512.61	27.12	56.76	192.33	223.91	12.39
Per cent. digested,	66.75	52.31	60.43	74.87	65.29	55.64

English Hay — Concluded.

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay fed, ...	767.98	51.84	93.92	256.89	342.96	22.27
283.50 grams manure excreted, . .	268.93	24.39	35.34	74.36	124.57	10.27
Grams digested, ...	499.05	27.45	58.58	182.53	218.39	12.00
Per cent. digested, ...	64.98	52.95	62.37	71.05	63.68	53.88
Average per cent. for three sheep, .	65.92	51.95	61.98	72.87	64.66	54.23

Average nutritive ratio of rations for three sheep, 1:7.5.

Green Diamond Sugar Feed. — Periods X. and XIV.

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams Green Diamond sugar feed fed.	367.80	36.34	50.43	56.16	215.05	9.82
500 grams English hay fed, ...	444.75	30.02	54.39	148.77	198.67	12.90
Amount consumed, ...	812.55	66.36	104.82	204.93	413.72	22.72
270.80 grams manure excreted, . .	254.80	37.46	34.86	62.35	113.18	6.96
Grams digested, ...	557.75	28.90	69.96	142.58	300.54	15.76
Minus hay digested, ...	301.85	14.76	33.89	113.51	131.90	6.76
Sugar feed digested, ...	255.90	14.14	36.07	29.07	168.64	9.00
Per cent. digested, ...	69.58	38.91	71.52	51.76	78.42	91.65

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
300 grams Green Diamond sugar feed,	268.86	26.56	36.86	41.05	157.20	7.18
500 grams English hay fed, ...	450.85	30.43	55.14	150.81	201.39	13.07
Amount consumed, ...	719.71	56.99	92.00	191.86	358.59	20.25
274.5 grams manure excreted, . .	259.18	33.75	33.15	65.86	118.16	8.27
Grams digested, ...	460.53	23.24	58.85	126.00	240.43	11.98
Minus hay digested, ...	295.21	13.57	33.93	111.31	129.82	6.56
Sugar feed digested, ...	165.32	9.67	24.92	14.69	110.61	5.42
Per cent. digested, ...	61.49	36.41	67.61	35.79	70.36	75.49
Average per cent. for both sheep, .	65.54	37.66	69.57	43.78	74.39	83.57

Average nutritive ratio of rations for two sheep, 1: 6.8.

Sea Island Cotton-seed Meal. — Period XI.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
200 grams Sea Island cotton-seed meal fed.	181.94	9.46	49.69	35.79	75.45	11.55
650 grams English hay fed,	590.98	39.89	72.28	197.68	263.99	17.14
Amount consumed,	772.92	49.35	121.97	233.47	339.44	28.69
296.70 grams manure excreted,	276.41	23.96	39.17	90.52	114.18	8.57
Grams digested,	496.51	25.39	82.80	142.95	225.26	20.12
Minus hay digested,	386.97	17.79	44.47	145.91	170.17	8.60
Cotton-seed meal digested,	109.54	7.60	38.33	–	55.09	11.52
Per cent. digested,	60.21	80.34	77.14	–	73.02	99.74

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	772.92	49.35	121.97	233.47	339.44	28.69
267 grams manure excreted,	248.23	23.16	37.73	73.13	106.39	7.82
Grams digested,	524.69	26.19	84.24	160.34	233.05	20.87
Minus hay digested,	386.97	17.79	44.47	145.91	170.17	8.60
Cotton-seed meal digested,	137.72	8.40	39.77	14.43	62.88	12.27
Per cent. digested,	75.69	88.79	80.04	40.32	83.34	100+
Average per cent. for both sheep,	67.95	84.56	78.39	40.32	78.18	100

Average nutritive ratio of rations for two sheep, 1:5.1.

Red Wheat Meal. — Period XII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	489.06	33.01	59.81	163.59	218.46	14.18
300 grams red wheat meal fed,	262.29	5.04	26.12	7.84	215.94	7.34
Amount consumed,	751.35	38.05	85.93	171.43	434.40	21.52
209.80 grams manure excreted,	197.74	19.60	30.97	49.08	90.19	7.91
Grams digested,	553.61	18.45	54.96	122.35	344.21	13.61
Minus hay digested,	322.39	17.15	37.07	119.21	141.26	7.69
Red wheat meal digested,	231.22	1.30	17.89	3.14	202.95	5.92
Per cent. digested,	88.15	25.79	68.49	40.05	93.98	80.65

Red Wheat Meal — Concluded.

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	751.35	38.05	85.93	171.43	434.40	21.52
223.20 grams manure excreted,	210.19	19.42	31.70	54.33	96.73	8.01
Grams digested,	541.16	18.63	54.23	117.10	337.67	13.51
Minus hay digested,	322.39	17.15	37.07	119.21	141.26	7.69
Red wheat meal digested,	218.77	1.48	17.16	–	196.41	5.82
Per cent. digested,	83.41	29.37	65.70	–	90.96	79.29
Average per cent. for both sheep,	85.78	27.58	67.10	–	92.47	79.97

Average nutritive ratio of rations for two sheep, 1: 9.

Leaming Corn Silage. — Period XIII.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed,	360.68	24.35	44.11	120.65	161.12	10.46
1,600 grams corn silage fed,	343.04	20.82	34.96	89.40	188.29	9.57
Amount consumed,	703.72	45.17	79.07	210.05	394.41	20.03
240.40 grams manure excreted,	226.26	23.71	31.00	56.90	108.04	6.61
Grams digested,	477.46	21.46	48.07	153.15	241.37	13.42
Minus hay digested,	244.79	11.97	27.48	92.06	106.97	5.48
Corn silage digested,	232.67	9.49	20.59	61.09	134.40	7.94
Per cent. digested,	67.82	45.58	58.89	68.33	71.38	82.97

Old Sheep III.

Amount consumed as above,	703.72	45.17	79.07	210.05	349.41	20.03
224.20 grams manure excreted,	211.17	21.94	27.49	53.09	102.35	6.29
Grams digested,	492.55	23.23	51.58	157.96	247.06	13.74
Minus hay digested,	244.79	11.97	27.48	92.06	106.97	5.48
Corn silage digested,	247.76	11.26	24.10	65.90	140.09	8.26
Per cent. digested,	72.22	54.08	68.93	73.71	74.40	86.31
Average per cent. for both sheep,	70.02	49.83	63.91	71.02	72.89	84.64

Average nutritive ratio of rations for two sheep, 1: 8.6.

White Winter Wheat Meal. — Period XV.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	537.60	36.29	65.75	179.83	240.15	15.59
250 grams wheat meal fed,	219.50	4.17	28.69	5.22	176.68	4.74
Amount consumed,	757.10	40.46	94.44	185.05	416.83	20.33
218.60 grams manure excreted,	203.89	21.18	29.97	49.97	93.83	8.93
Grams digested,	553.21	19.28	64.47	135.08	323.00	11.40
Minus hay digested,	354.39	18.85	40.75	131.04	155.28	8.45
Wheat meal digested,	198.82	.43	23.72	4.04	167.72	2.95
Per cent. digested,	90.58	10.31	82.68	77.39	94.93	62.24

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	757.10	40.46	94.44	185.05	416.83	20.33
229.90 grams manure excreted,	214.01	19.58	30.48	56.28	98.94	8.73
Grams digested,	543.09	20.88	63.96	128.77	317.89	11.60
Minus hay digested,	354.39	18.85	40.75	131.04	155.28	8.45
Wheat meal digested,	188.70	2.03	23.21	–	162.61	3.15
Per cent. digested,	85.97	48.68	80.90	–	92.04	66.46
Average per cent. for both sheep,	88.28	29.50	81.79	–	93.49	64.35

Average nutritive ratio of rations for two sheep, 1: 7.4.

Feed Barley Meal. — Period XVI.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	491.43	33.17	60.10	164.38	219.52	14.25
250 grams feed barley fed,	222.68	7.28	32.51	13.78	164.56	4.54
Amount consumed,	714.11	40.45	92.61	178.16	384.08	18.79
203.20 grams manure excreted,	188.89	23.61	26.18	43.60	87.76	7.74
Grams digested,	525.22	16.84	66.43	134.56	296.32	11.05
Minus hay digested,	321.79	14.79	36.98	121.33	141.50	7.15
Feed barley digested,	203.43	2.05	29.45	13.23	154.82	3.90
Per cent. digested,	91.36	28.16	90.06	96.01	94.08	85.90

Feed Barley Meal — Concluded.

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	714.11	40.45	92.61	178.16	384.08	18.79
215 grams manure excreted,	199.52	22.23	27.65	50.66	91.28	7.70
Grams digested,	514.59	18.22	64.95	127.50	292.80	11.09
Minus hay digested,	321.79	14.79	36.98	121.33	141.50	7.15
Feed barley digested,	192.80	3.43	27.97	6.17	151.30	3.94
Per cent. digested,	86.58	47.12	86.10	44.78	91.94	86.78
Average per cent. for both sheep,	88.97	37.64	88.08	70.40	93.01	86.34

Average nutritive ratio of rations for two sheep, 1:6.8.

Summary of Coefficients.

Food.	Sheep and Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Early Amber Sorghum.	Paige Sheep IV.,	69.36	42.98	45.36	71.72	74.04	60.39
	Paige Sheep V.,	67.37	40.45	50.91	65.22	73.35	65.10
	Average,	68.37	41.72	48.14	68.47	73.70	62.75
Pride of the North corn fodder.	Old Sheep II.,	71.89	40.06	64.45	66.50	77.76	78.37
	Old Sheep III.,	69.22	28.81	61.03	63.14	76.32	73.75
	Average,	70.56	34.43	62.74	64.82	77.04	76.06
Porto Rico molasses.	Paige Sheep IV.,	107.09	92.16	40.43	–	102.76	–
	Paige Sheep V.,	90.93	80.02	10.17	–	95.80	–
	Average,	99.01	86.09	25.30	–	99.28	–
Porto Rico molasses.	Paige Sheep IV.,	91.89	47.38	–	–	95.35	–
	Paige Sheep V.,	88.21	57.74	–	–	95.30	–
	Average,	90.05	52.56	–	–	95.33	–
English hay,	Paige Sheep IV.,	66.05	43.76	60.86	75.44	64.85	49.88
	Paige Sheep V.,	64.90	45.44	62.20	72.18	64.06	50.51
	Average,	65.48	44.60	61.53	73.81	64.46	50.20
English hay,	Old Sheep II.,	69.38	51.01	63.20	78.04	68.29	55.21
	Old Sheep III.,	66.36	47.33	61.41	74.55	65.56	49.53
	Average,	67.87	49.17	62.31	76.30	66.39	52.37

Summary of Coefficients — Concluded.

Food.	Sheep and Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Gluten feed,	Paige Sheep IV.,	93.78	78.07	89.26	123.46	93.42	75.70
	Paige Sheep V.,	97.83	98.67	92.91	128.92	97.03	79.68
	Average,	95.81	88.37	91.09	126.19	95.23	77.69
Porto Rico molasses.	Paige Sheep IV.,	76.50	64.12	–	–	86.93	–
	Paige Sheep V.,	72.53	65.25	–	–	84.80	–
	Average,	74.52	64.69	–	–	85.87	–
English hay,	Young Sheep I.,	66.04	50.60	63.15	72.68	65.01	53.17
	Young Sheep II.,	66.75	52.31	60.43	74.87	65.29	55.64
	Young Sheep III.,	64.98	52.95	62.37	71.05	63.68	53.88
	Average,	65.92	51.95	61.98	72.87	64.66	54.23
Green Diamond sugar feed.	Old Sheep III.,	69.58	38.91	71.52	51.76	78.42	91.65
	Paige Sheep IV.,	61.49	36.41	67.61	35.79	70.36	75.49
	Average,	65.54	37.66	69.57	43.78	74.39	83.57
Sea Island cotton-seed meal.	Paige Sheep IV.,	60.21	80.34	77.14	–	73.02	99.74
	Paige Sheep V.,	75.69	88.79	80.04	40.32	83.34	100+
	Average,	67.95	84.56	78.39	40.32	78.18	100.00
Red wheat meal,	Young Sheep I.,	88.15	25.79	68.49	40.05	93.98	80.65
	Young Sheep III.,	83.41	29.37	65.70	–	90.96	79.29
	Average,	85.78	27.58	67.10	–	92.47	79.97
Leaming corn silage.	Old Sheep II.,	67.82	45.58	58.89	68.33	71.38	82.97
	Old Sheep III.,	72.22	54.08	68.93	73.71	74.40	86.31
	Average,	70.02	49.83	63.91	71.02	72.89	84.64
White winter wheat meal.	Young Sheep I.,	90.58	10.31	82.68	77.39	94.93	62.24
	Young Sheep III.,	85.97	48.68	80.90	–	92.04	66.46
	Average,	88.28	29.50	81.79	–	93.49	64.35
Feed barley meal.	Paige Sheep IV.,	91.36	28.16	90.06	96.01	94.08	85.90
	Paige Sheep V.,	86.58	47.12	86.10	44.78	91.94	86.78
	Average,	88.97	37.64	88.08	70.40	93.01	86.34

Discussion of the Results.

Early Amber Sorghum. — This seed was sown broadcast May 25 at the rate of 60 pounds to the acre, and the crop was cut for soiling. It made a satisfactory growth, yielding at the rate of 19 tons to the acre. The digestion trial began August 13, as the sorghum was heading out, and the fæces were collected August 20 to 26, when the plants were fully headed and the seed forming, at which period it is probably at its best for soiling purposes.

Summary of the Coefficients (Per Cent.).

Period I.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	69.36	42.98	45.36	71.72	74.04	60.39
Paige Sheep V.,	1	1	67.37	40.45	50.91	65.22	73.35	65.10
Average,	1	2	68.37	41.72	48.14	68.47	73.70	62.75
Barnyard millet for comparison.	3	6	70.00	56.00	65.00	73.00	71.00	58.00
Corn fodder (immature) for comparison.	5	14	68.00	42.00	66.00	65.00	71.00	68.00

The two trials with the sheep agree quite well with each other, and likewise with millet and corn fodder at a similar stage of growth. The protein only seems to be less digestible than that contained in the other two fodders. Sorghum is eaten well by dairy cattle, is available just before corn is sufficiently mature to be at its best, and is considered a satisfactory addition to the list of soiling crops for Massachusetts. A fuller discussion of the merits of this plant for soiling will be presented later.

Pride of the North Dent Corn Fodder. — The samples were taken from a large field of exceptionally thrifty and well-eared fodder. The stalks were quite stout and the ears fully developed. Sampling was begun September 5, and the fæces were collected September 13 to 19, at which time the grain was in the dough and denting. The entire plant was cut fine before being fed. It contained 77.4 per cent. water and 8.83 per cent. protein in dry matter.

Summary of the Coefficients (Per Cent.).

Period II.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	71.89	40.06	64.45	66.50	77.76	78.37
Old Sheep III.,	1	1	69.22	28.81	61.03	63.14	76.32	73.75
Average,	1	2	70.56	34.43	62.74	64.82	77.04	76.06
Average all experiments, Dent corn fodder for comparison.	9	17	68.00	34.00	53.00	57.00	73.00	74.00

The two sheep consumed the fodder readily, suffered no digestion disturbances and gave closely agreeing results. The average coefficients secured with the two sheep agree as closely as could be expected with the average of all results for mature Dent fodder. The present experiment shows in a very satisfactory manner the degree of digestibility of an excellent variety of Dent fodder that will mature in Massachusetts.

Porto Rico Molasses. — Molasses from Porto Rico has been freely offered in Massachusetts for cattle feeding at a cost of 13 cents a gallon of 12 pounds in barrel lots. The material, while dark colored, was of a satisfactory quality. It contained 20 to 28 per cent. of water (about 24 per cent. average), and in its natural condition about 3 per cent. of crude protein (largely amids), 6.3 per cent. of ash, and the balance cane and invert sugars and allied substances (extract matter). It can be safely assumed that molasses, being quite soluble in water, is easily digested and resorbed in the digestive tract. Three digestion experiments were made by feeding different quantities of the molasses in combination with hay, and hay and gluten feed, in order to note its effect upon the digestion of the other feed stuffs.[1]

[1] It is a well-known fact that the addition of excessive quantities of starch and sugar causes a distinct depression in digestibility of the other feed stuffs. See summary in Kellner (already cited), page 48.

Summary of the Coefficients (Per Cent.).

Period III.

[800 grams hay, 150 grams molasses and 10 grams salt.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	107.09	92.16	40.43	-	102.76	-
Paige Sheep V., ...	1	1	90.93	80.02	10.17	-	95.80	-
Average, ...	1	2	99.01	86.09	25.30	-	99.28	-

The results show that apparently Sheep IV. digested rather more, and Sheep V. some 9 per cent. less, than the quantity fed. The average coefficients for the two sheep indicate that the dry matter of the molasses was fully digested. It is probably true, however, that in case of Sheep IV. the addition of 150 grams of molasses to the hay ration increased the digestibility of the dry matter of the hay some 7 per cent., and in case of Sheep V. decreased the digestibility of the hay about a like amount. The results can be still further explained by the following figures: —

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of 800 grams hay fed alone (grams).	408.87	23.43	32.85	133.86	210.30	8.12
Digested of 800 grams hay + 150 grams molasses.	523.71	31.78	34.56	141.89	306.85	8.54
Minus 150 grams molasses fed, assumed to be all digested (grams).	107.24	9.06	4.23	-	93.95	-
Leaves for 800 grams hay digested when fed with molasses.	416.47	22.72	30.33	141.89	212.90	8.54
Difference, ...	+7.60	—.71	—2.52	+8.03	+2.60	+.42

It will be seen that in case of Sheep IV. the feeding of 150 grams of molasses with 800 grams of hay increased the digestibility of the hay 7.6 grams. By this method of feeding the digestibility of the fiber, extract matter and fat in the hay was increased 11.05 grams and the digestibility of the ash and protein depressed 3.23 grams. If 150 grams of molasses increased the digestibility of the hay 7.32 grams (7.60), 100 grams of molasses would increase it 5.1 grams.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digestion of 800 grams hay fed alone (grams).	408.87	23.43	32.85	133.86	210.30	8.12
Digested of 800 grams hay + 150 grams molasses (grams).	506.38	30.68	33.28	133.82	300.30	8.31
Minus 150 grams molasses fed assumed to be all digested (grams).	107.24	9.06	4.23	-	93.95	-
Leaves for 800 grams hay digested when fed with molasses.	399.14	21.62	29.05	133.82	206.35	8.31
Difference, ...	—9.73	—1.81	—3.80	—.04	—3.95	+.19

Sheep V. digested 9.36 (9.73) grams less hay when the latter was fed with the molasses than when it was fed alone, or 100 grams of molasses caused a depression of 6.05 grams in the digestibility of the hay. The results secured in this particular experiment (Period III.) are contradictory, and definite conclusions cannot be drawn other than to conclude that this quantity of molasses was well assimilated, without causing any serious digestion depression.

Period IV.

[800 grams hay + 250 grams molasses + 10 grams salt.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	91.89	47.38	-	-	95.35	-
Paige Sheep V., ...	1	1	88.21	57.54	-	-	95.30	-
Average, ...	1	2	90.05	52.56	-	-	95.33	-

It seems apparent that 90 per cent. of the total dry matter of the molasses was digested, equivalent to one-half of the ash, none of the protein and 95 per cent. of the extract matter. That these results are more apparent than real can be shown from the following: —

Average, Sheep IV. and V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of 800 grams hay fed alone (grams).	404.56	23.19	32.51	132.44	208.07	8.03
Digested of 800 grams hay + 250 grams molasses (grams).	566.92	31.20	32.04	136.99	358.65	8.06
Minus 250 grams molasses fed, assumed to be all digested (grams).	180.30	15.24	7.10	-	157.96	-
Leaves for 800 grams hay digested when fed with molasses.	386.62	15.96	24.94	136.99	200.69	8.06
Difference, ...	−17.94	−7.23	−7.57	+4.55	−7.38	+.03

The average results for the two sheep show that 17.94 (17.60) grams less hay were digested when 250 grams of molasses were fed than when the hay was fed by itself; or 100 grams of molasses caused a depression of 7.2 grams in the digestibility of the dry matter of the hay. The molasses depressed the digestibility of the ash, protein and extract matter of the hay. Excluding the ash, 100 grams of molasses caused a depression of 4.1 grams in the digestibility of the organic matter of the hay. Molasses and hay naturally would not make a satisfactory combination for any kind of farm stock. A more suitable ration would consist of hay, a protein concentrate and molasses; consequently, the digestibility of the latter was tested in combination with hay and gluten feed, with the following results: —

Period VIII.

[600 grams hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	76.50	64.12	-	-	86.93	-
Paige Sheep V., ...	1	1	72.53	65.25	-	-	84.80	-
Average, ...	1	2	74.52	64.59	-	-	85.87	-

It is apparent from the above results that the sheep digested only some 75 per cent. of the total dry matter of the molasses. By assuming that the entire quantity of molasses fed was digested, the following results are secured: —

Average, Sheep IV and V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of hay and gluten feed when fed *without* molasses (grams).	524.97	18.75	81.88	148.40	264.22	11.74
Digested of hay and gluten feed fed with molasses.	660.31	29.58	79.47	139.96	399.66	11.61
Minus 250 grams molasses fed, assumed to be all digested (grams).	181.68	16.75	7.16	-	157.77	-
Hay and gluten feed digested when fed *with* molasses (grams).	478.63	12.83	72.31	139.96	241.89	11.61
Difference, ...	—46.34	—5.92	—9.57	—8.44	—22.33	—.13

The average results for the two sheep show that 46.34 grams less of the dry matter of the hay and gluten feed were digested with than without the molasses; or 100 grams of molasses caused a depression of 18.5 grams in the digestibility of the hay and gluten ration. Excluding the ash, 100 grams of molasses caused a depression of 3.8 grams protein and 12.3 non-protein substances.

When 250 grams of molasses were fed in connection with hay, the digestion depression for organic matter was at the rate of 4 grams per 100 grams molasses; and when fed in connection with hay and a nitrogenous concentrate, the digestion depression was 16.1 grams. It is intended to repeat the latter experiment by feeding different quantities of molasses with hay and gluten feed, in order to see if the depression continues as high as that observed in the present test.

The average of three complete analyses of Porto Rico molasses has shown it to contain, in round numbers, 24 per cent. of water, 6.25 per cent. ash, 2.75 per cent. protein and 67 per cent. carbohydrates. Inasmuch as the so-called protein is practically all in amido or other forms which are of no value as sources of nutrition, it may be said that the food value of molasses consists in its 67 per cent. of carbohydrates. Applying the digestion coefficient of 86, obtained for the digestibility of the extract matter when the molasses was fed in combination with hay and gluten feed, one obtains 58 per cent. of digestible carbohydrates, equivalent to 1,160 pounds in a ton.

By deducting 16 grams, or 16 pounds (for the digestion depression), from the 70 per cent. of total organic matter, molasses may be said to contain 54 per cent. of digestible organic matter, equivalent to 1,080 pounds in a ton. In the light of the above results, it is evident that 2,000 pounds of Porto Rico molasses contain between 1,080 and 1,160 of easily digestible carbohydrates, and that its crude protein has little or no value as a source of nutrition.[1]

Kellner[2] considers the value of beet sugar molasses to consist in its 55 per cent. of digestible carbohydrates, allowance being made for the digestion depression. Lehmann,[3] as a result of three digestion experiments (9 single trials), feeding hay, cotton-seed or palm-nut meal, and 200, 300 and 400 grams of molasses, secured a digestion depression of 11 per cent., or 11 grams, per 100 grams of molasses fed. Deducting this from the 71 per cent. of organic matter, he declares the value of the beet molasses to consist in its 60 per cent. of digestible carbohydrates.

English Hay. — This hay consisted largely of Kentucky blue grass (*Poa pratensis*), with an admixture of more or less red clover. It was cut when in bloom, well cured, and used in periods V., VI., VII., VIII., IX., XI., XII., XIII., XIV., XV. and XVI.

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1 One is not likely to feed over 3 pounds of molasses daily to dairy stock or to horses, which is equivalent to approximately 10 per cent. of the dry matter of the total ration. In our digestion experiment with hay and gluten feed, molasses constituted 20 per cent. of the dry matter of the ration; and in Lehmann's experiments, 25 per cent. If only 10 per cent. of the total dry matter in the daily ration should consist of molasses, the question naturally arises as to whether this amount would cause so much of a depression as when larger quantities were fed. This matter is being investigated.

2 Kellner (already cited), page 350.

3 Landw. Jahrbücher, Vol. XXV. Ergänzungsband 11, 1894, pages 117-120.

Summary of the Coefficients (Per Cent.).

Periods V., VI., IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	66.05	43.76	60.86	75.44	64.85	49.88
Paige Sheep V.,	1	1	64.90	45.44	62.20	72.18	64.06	50.51
Average,	1	2	65.48	44.60	61.53	73.81	64.46	50.20
Old Sheep II.,	1	1	69.38	51.01	63.20	78.04	68.29	55.21
Old Sheep III.,	1	1	66.36	47.33	61.41	74.55	65.56	49.53
Average,	1	2	67.87	49.17	62.31	76.30	66.39	52.37
Young Sheep I.,	1	1	66.04	50.60	63.15	72.68	65.01	53.17
Young Sheep II.,	1	1	66.75	52.31	60.43	74.87	65.29	55.64
Young Sheep III.,	1	1	64.98	52.95	62.37	71.05	63.68	53.88
Average,	1	3	65.92	51.95	61.98	72.87	64.66	54.23
Average, seven sheep,	1	7	66.35	49.05	61.95	75.55	65.10	52.55
Average all previous trials, similar hay for comparison.	15	60	60.00	47.00	57.00	60.00	61.00	50.00

The three lots of sheep digested the hay quite uniformly. The Old Sheep gave slightly higher digestion coefficients than the other two lots, — a condition which has been noticed in previous trials. The hay proved to have a higher digestibility than the average of previous lots; the high digestibility of the fiber indicates that the lignin substances were only slightly developed, or, in other words, that the grass was tender and comparatively immature.

Gluten Feed. — The sample of gluten feed, consisting of the gluten, skins, starchy matter and broken germs of the Indian corn, was in good condition, although a little below the average in protein.

Summary of Coefficients (Per Cent.).

Period VIII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., . . .	1	1	93.78	78.07	89.26	123.46	93.42	75.70
Paige Sheep V., . . .	1	1	97.83	98.67	92.91	128.92	97.03	79.68
Average, ...	1	2	95.81	88.37	91.09	126.19	95.23	77.69
Average previous trials for comparison.	7	13	86.00	–	85.00	76.00	89.00	83.00

The gluten feed appears to have been thoroughly digested, showing higher coefficients than the average of previous trials. It is probable that the addition of the gluten to the hay ration somewhat increased the digestibility of the latter. It not being possible, however, to ascertain to what extent this increase took place, one is compelled to deduct from the total ration the hay digested (using the coefficients obtained for the hay when fed by itself), thus causing most of the gluten coefficients to appear too high [1] (note especially the fiber).

Green Diamond Sugar Feed. — This sugar feed has a similar appearance and is of the same general type as those already reported (see this report, pages 236, 237). Period X. started with two sheep, but the fæces produced by one sheep were so soft that it was not possible to complete the test. Another trial with another sheep was also unsatisfactory. A third trial, in Period XIV., with Paige Sheep IV., was satisfactorily completed.

Summary of Coefficients (Per Cent.).

Periods X. and XIV.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep III., ...	1	1	69.58	38.91	71.52	51.76	78.42	91.65
Paige Sheep IV., . . .	1	1	61.49	36.41	67.61	35.79	70.36	75.49
Average, ...	1	2	65.54	37.66	69.57	43.78	74.39	83.57
Average of three other sugar feeds (Series X.).	3	6	70.44	30.37	61.77	53.30	78.40	88.20
Average all trials, . . .	4	8	69.21	32.20	63.72	50.92	77.40	87.04

[1] The addition of a concentrated feed rich in protein tends to improve the digestibility of the total ration, especially the fiber. (See Kellner, *loco citato*, pages 51–53.)

Sheep III. digested the feed rather better than Sheep IV. Attention has already been called to the fact that the Old Sheep had a slightly stronger digestion than the others, but why the difference should be so noticeable is difficult to explain.

The protein in the sample of Green Diamond experimented with was better digested than that in the several other sugar feeds. The results secured with Sheep III. and the average results of all trials agree closely; and it may safely be said that this feed has about the same type of composition and a like degree of digestibility as the other sugar feeds examined. The average results of all trials show the sugar feeds to be only moderately digestible, being noticeably less so than either flour middlings or gluten feed.

Sea Island Cotton-seed Meal. — This meal contained a large quantity of hulls, showing only 24–25 per cent. of protein, 5–6 per cent. of fat and some 18 per cent. of fiber. It is claimed that the hulls of this variety of seed are thin, and that it is not possible (or profitable) to thoroughly separate them from the meats.

Summary of Coefficients (Per Cent.).

Period XI.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	60.21	80.34	77.14	–	73.02	99.74
Paige Sheep V.,	1	1	75.69	88.79	80.04	40.32	83.34	100+
Average,	1	2	67.95	84.56	78.59	40.32	78.18	100.00
Similar material (Maine),	1	2	62.00	–	73.00	38.00	68.00	90.00
Cotton-seed meal (high grade),	4	12	79.00	84.00	84.00	35.00	78.00	94.00

Sheep IV. was not able to digest the meal as fully as was Sheep V. The cause of this difference is due largely to the indigestible character of the tough, woody fiber. The coefficients secured at the Maine station for a similar meal are somewhat lower than those obtained in the present experiment.

The fat in the low-grade meal is shown to be nearly all

available, while the protein is somewhat less digestible than that contained in a high-grade meal; the chief difference, however, in the digestibility of the two grades is to be found in the total dry and extract matter, decidedly lower coefficients being secured from the low-grade meal containing a high fiber percentage. Cotton-seed meal of first quality should contain in 2,000 pounds about 700 to 760 pounds protein, 44 pounds fiber, 380 pounds extract matter and 192 pounds fat, or 1,346 pounds digestible organic matter in one ton. A low-grade meal will contain 380 pounds protein, 144 pounds fiber, 540 pounds extract matter and 142 pounds fat, or 1,206 pounds digestible organic matter in a ton. The low-grade meal contains only about one-half as much of the most valuable ingredient (digestible protein) as does the high-grade meal. The former meal will likewise require considerably more energy for its digestion.

Leaming Corn Silage. — The Leaming corn is a large dent, that will usually mature its grain in Massachusetts. The silage was in nice condition, and was made from matured and well-eared corn. The sheep ate the silage well, continued in good condition, and during the entire trial left only 25 and 40 grams each of the hard butts.

Period XIII.

[400 grams hay, 1,600 grams silage, 10 grams salt.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	67.82	45.58	58.89	68.33	71.38	82.97
Old Sheep III., ...	1	1	72.22	54.08	68.93	73.71	74.40	86.31
Average, ...	1	2	70.02	49.83	63.91	71.02	72.89	84.64
Dent silage, mature, all trials for comparison.	9	25	66.00	37.00	50.00	64.00	71.00	82.00

The two sheep showed closely agreeing results except in case of the protein, Sheep III. digesting 10 per cent. more than Sheep II. The Leaming corn is highly esteemed by many farmers for silage purposes; and the fact that it will generally mature its grain, together with its high degree of digestibility,

as shown by the above coefficients, shows the preference to be a wise one. The average results of the two trials are rather higher than the general average of all experiments with different varieties of Dent corn.

Red and White Wheat and Barley Meals. — The several grains were purchased of local dealers. Neither variety of wheat was suitable for milling; the former contained some shrunken berries and a few weed seeds, and the latter, while fairly plump, was off color. The barley was known as "feed barley;" it was not plump and full, and was a trifle musty. The grains were sold as food for poultry, and may be considered of a fairly satisfactory quality for such a purpose. The red wheat retailed at $1.65, the white at $1.80 and the barley at $1.30 per hundred pounds. The analyses and the digestion trials were made for the purpose of ascertaining their relative values for feeding purposes.

Composition (Per Cent.).

Feed.	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Red wheat,	12	1.69	8.76	2.64	72.45	2.46
White wheat,	12	1.67	11.50	2.11	70.84	1.90
Feed barley,	11	2.91	12.99	5.52	65.78	1.80

Each of the two samples of wheat contained a trifle less than 12 per cent. water, and the results were therefore calculated to that basis for comparison. The white wheat tested a little better than the red, containing nearly 3 per cent. more protein and a little less fiber. It is doubtful, however, if these figures would hold true in all cases. In fact, it is well known that both climate and soil have great influence on the quality of wheat and gradually modify varieties.

The barley showed rather more protein than is usually found in this grain. It is probable that it had not been fully ripened when cut, thus preventing the most complete development of the starch.

Summary of Coefficients (Per Cent.).

Periods XII., XV. and XVI.

[Red Wheat.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	88.15	25.79	68.49	40.05	93.98	80.65
Young Sheep III.,	1	1	83.41	29.37	65.70	–	90.96	79.29
Average,	1	2	85.78	27.58	67.10	–	92.47	79.97

[White Wheat.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	90.58	10.31	82.68	77.39	94.93	62.24
Young Sheep III.,	1	1	85.97	48.68	80.90	–	92.04	64.35
Average,	1	2	88.28	29.50	81.79	–	93.49	63.30
Average, both varieties,	2	4	87.03	28.54	74.44	–	93.00	71.30

[Feed Barley.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	91.36	28.16	90.06	96.01	94.08	85.90
Paige Sheep V.,	1	1	86.58	47.12	86.10	44.78	91.94	86.78
Average,	1	2	88.97	37.64	88.08	76.40	93.01	86.34
Corn for comparison,	9	21	88.00	–	66.00	–	92.00	91.00

The grains were ground in each case before being fed. Both varieties of wheat were well digested; the white wheat appeared to have been slightly better digested than the red. The barley was likewise quite fully digested, showing 89 per cent. of digestible dry matter and 88 per cent. of digestible protein. The ratio of digestible protein to carbohydrates in the red wheat was 1 to 9; in the white wheat, 1 to 7.4; and in the barley, 1 to 6.8. The increased digestibility of the protein in the white wheat and feed barley over that contained in the red wheat is due probably to the relatively higher percentage of protein in the latter two grains, and consequently in the two total rations.[1] It is believed that the protein in ordinary grains (maize, wheat and barley) is equally and quite fully digested, providing it is fed in a ration having a ratio of 1 to 8 or less; and that the apparent

[1] For every 100 grams of dry matter fed, a reasonably definite amount of nitrogenous metabolic by-products are egested, mixed with the fæces, whether the ration is rich or poor in protein. It follows, therefore, that the smaller the amount of protein in the total ration the smaller will be the amount of protein left (digested) after these by-products which are included in the fæces have been deducted.

low coefficient (see present red wheat protein coefficient, and average protein coefficients for maize) is due largely to the above-mentioned cause.[1] A further study of the coefficients of wheat, barley and corn, as given on the previous pages, shows the extract matter to have practically the same degree of digestibility.[2]

On the basis of composition and of the digestion coefficients secured, the white variety of wheat is shown to be some 9 per cent. more valuable than the red. Whether this would hold true as a general rule is not known. Other things being equal, the higher the protein content of the wheat the more valuable it is.

Taking the value of all the ingredients into consideration (protein, fiber, extract matter and fat), an average quality of "feed barley" appears to be about as valuable as an average quality of white wheat, and both grains figure slightly more valuable than maize (8 per cent.). Kellner[3] considers these three grains to have very nearly equal relative values, and as sources of carbohydrates this estimate must be correct. Brooks[4] has called attention to the fact that, with a plentiful supply of animal protein, corn gives rather better results than wheat for egg production, and at less relative cost. In view of their composition and digestibility, it would seem as if there were no reason to expect any particular difference in the feeding effect of these two grains. It is possible, however, that the energy required for the digestion of the wheat might be greater than that required to digest the corn. It is well known that poultry are particularly fond of corn and moderately so of wheat, but do not care especially for barley. This fact should not be overlooked in comparing the relative merits of corn, wheat and barley for this class of stock.

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[1] For every 100 grams of dry matter fed, a reasonably definite amount of nitrogenous metabolic by-products are egested, mixed with the fæces, whether the ration is rich or poor in protein. It follows, therefore, that the smaller the amount of protein in the total ration the smaller will be the amount of protein left (digested) after these by-products which are included in the fæces have been deducted.

[2] The digestion experiments thus far made with poultry show the dry matter in corn to be 87, protein 84 and extract matter 92 per cent. digestible; and in wheat dry matter 84, protein 77 and extract matter 89 per cent. digestible. In other words, poultry digest the two grains to about the same extent as sheep.

[3] *Loco citato*, page 561.

[4] Eighteenth report of this station, page 152.

REPORT OF THE BOTANIST.

G. E. STONE; ASSISTANT, N. F. MONAHAN.

Outline of Work.

The work of this department has been devoted during the past year to lines of investigation pertaining to scientific and practical problems. Attention has been given to the spraying of potatoes, and to a study of the stimulating or tonic influence of the Bordeaux mixture on the photosynthesis of plants. It has long been recognized by many observers that Bordeaux mixture, besides possessing valuable fungicidal properties, exerts a tonic effect on plant assimilation. The factors underlying the cause of this favorable influence upon assimilation, however, are not well understood, and investigations are to be continued relating to this problem.

A continuation of our studies of a remedy for tomato rot under glass has been carried on, and it will be necessary to continue these investigations still further before a report is made. It is hoped that the necessary funds for a new greenhouse will be appropriated this winter by the Legislature, in order that this work and other problems associated with greenhouse culture may be investigated. There is a large amount of money invested in greenhouses at the present time in Massachusetts, and we believe we are within the limits of safety when we state that the square feet of greenhouse space in Massachusetts has been doubled within the past five years. Little attention has been given to this line of investigation by other stations, and the market-garden and florist industry is important enough, in this State at least, to receive considerable attention.

During the past summer tests have been made of some

blight-resisting cantaloupes which were originated in Colorado. It is hoped that further observations may be made on cantaloupes, with the idea of securing blight-resisting types, since at the present time crops of melons free from blight are a rarity in Massachusetts.

Some bacterial investigations have been carried on which possess a bearing on various problems, but it is not deemed advisable to report on this work at the present time.

This also holds true in regard to some minor experiments with electricity as related to plants. Extensive observations have been made in regard to the bearing of light upon plant growth, more particularly in regard to greenhouse construction and other problems.

During the coming year we expect to take up the study of some climatic influences which affect the production of both greenhouse and out-door crops. The production of crops is so intimately associated with such factors as light, heat, moisture, etc., — factors which are scarcely appreciated except by skilled greenhouse growers, — that a more extensive study of them would prove of value.

During the year a large number of mechanical analyses of soils have been made by this department, most of which were rose soils. These analyses were made for expert rose growers, who desired to secure suitable soils for the growth of American Beauty and other roses.

Seed Work.

There is a constantly increasing demand upon this department for work pertaining to seed germination, seed separation and purity testing of seeds. The department is not at present sufficiently well equipped for purity testing, since the best work in this line can be done only by a specialist, or by one who is able to devote considerable study to the subject.

Most of our seed separation is done for tobacco and onion growers of the Connecticut valley, and for this work the department has installed efficient appliances. It is hoped that market gardeners will eventually separate their seed, since in growing such crops as lettuce, celery, radishes, etc., this practice would prove valuable.

The following table gives a condensed statement of the work done by this department on seeds during the year: —

Records of Seed Work for 1906.

	Number of Samples.	Number of Seed.	Weight (Pounds).	Good Seed (Per Cent.).	Discarded Seed (Per Cent.).
Germination tests,	126	19,567	–	58.8	–
Purity test,	18	–	–	–	–
Seed separation: —					
Onion,	13	–	129.6	83.8	16.2
Tobacco,	74	–	24.1	80.3	19.7
Total,	231	–	–	–	–

The average percentage of germination of onion seed was 79.5; of sweet corn, 71.9; and the highest percentage of onion seed germination was 100, while the same percentage was obtained with samples of sweet corn. The lowest percentage of germination of onion was 28; that of sweet corn, 25. In practically all cases 200 seeds were employed in each test, and smaller numbers were used only when the number of seeds sent in was less. Occasionally more than one test was made, and the average in such cases was taken. The onion seeds tested during 1906 were particularly good, being much better than those we have tested during previous years. Both onion and tobacco seed were separated by air. Only 2 per cent. of seed was discarded by the process of air separation from the best tobacco seed sent in, while from the poorest samples 37 per cent. was discarded. In the case of the best onion seed, 8 per cent. was discarded by the use of a winnowing machine, while only 20 per cent. was discarded from the poorest samples of onion seeds.

Prevalence of Fungi, etc.

One of the peculiarities of the different seasons is that no two are alike as regards the prevalence of certain pathogenic fungi. The potato has been comparatively free from disease during the past season; but there was more or less trouble with celery, particularly in the summer, when there was a

period of rather dry weather; and later in the fall there was much complaint of celery blight. Pear and apple blight were unusually prevalent this year, more so than they have been for some time. An unusually large number of samples of pear and apple blight were sent in to the station for diagnosis during the spring and early summer. More or less defoliation of apple trees has occurred, resulting in part from the late spring frosts, which caused blisters on the leaves; and from the use of spraying mixtures.

A considerable amount of trouble is being experienced in the defoliation of apple trees at the present time in various parts of the United States, which is presumably caused by spraying. Some of this trouble is to be found in our State, and we surmise that it may be due in some cases to the use of inferior Paris green in Bordeaux mixture, and in other cases to the Bordeaux itself. The Baldwin apple spot has been more or less prevalent during the past season, and some trouble has been experienced from apple scab.

A widely distributed and common trouble has occurred on apple trees during the past season, which is termed sun scald. This was more noticeable on small branches, particularly on those which were shaded. This same diseased condition was noticeable on other fruit trees, such as the peach and plum; and on some wild shrubs, like the cornels. The effect of sun scald was in some instances of an insignificant nature; while in others it resulted in a partial girdling of some of the branches, which was followed by a poor development of the foliage, and in some cases many of the twigs died.

Sun scald is the result of a non-ripening of the wood; and it is significant that most of the branches affected with this trouble are those hidden from the sun, which prevents the wood from ripening as thoroughly as those which are exposed to the sun.

For the last two or three years sooty mold on the pear has given rise to considerable trouble. This is caused by fungi which grow in the honey-dew secreted by psylla on the leaves and branches. As a consequence of this fungous growth, there results a clogging of the pores of the leaves, which renders them unhealthy, causing them to fall prematurely. The

young twigs and branches become covered with a thick black growth, resembling soot, which interferes with their normal functions, thus checking their growth. A satisfactory way of ridding the branches of this sooty growth is not known to us at the present time, and from reports which we have received it would appear that the lime and sulfur treatment has no effect upon it. The best method of prevention is to kill the psylla, which can be effectively done by spraying.

Some incidental observations have been made during the year on diseases which are unusual, at least in this region; and these will be referred to briefly, since it is necessary that further studies of these be made before it can be ascertained whether they are likely to cause much trouble. Our attention has been called a few times to some greenhouse tomato troubles, one of which is probably the Fusarium wilt, or "sleeping disease," as it is termed, — a trouble which has been reported elsewhere.

Another tomato trouble which has been brought to our attention is probably identical with Œdema, and is caused by abnormal heat and moisture conditions. In another case a bacterial trouble of the tomato was observed which was undoubtedly brought about by the exceedingly poor management of the crop.

Two new or little-known asparagus troubles were noticed during the past season, one of which is undoubtedly a Rhizoctonia rot, which is mentioned as occurring on asparagus by Saccardo. We were not able to make an elaborate study of this asparagus infection, owing to the limited amount of material which was at hand. Most Rhizoctonia troubles are serious, and it remains to be seen whether this will prove to be so or not.

Bacterial Disease of Cucumbers.

The bacterial disease of cucumbers, termed by Dr. Erwin R. Smith "bacteriosis," has been seen here in summer for some years on out-door cucumber crops. My attention, however, has not been called to its appearance on greenhouse crops until this year; but if the reports and descriptions of this disease are correct, it has occurred in more than one greenhouse during the year.

In only one case have we had opportunity to examine an affected crop, and this was totally destroyed during October. This crop was started in August, and, like most crops of cucumbers started in midsummer, it was affected with downy mildew (*Plasmopara Cubensis,* B. & C., Humphrey). The soil in the house was of good texture for cucumbers, and well provided with horse manure and commercial fertilizers, as was evident from the vigorous growth of the plants. About the time the plants had reached a height of seven or eight feet and had set a large amount of fruit the leaves commenced to wilt, and in a few days most of the foliage collapsed, leaving only a few unaffected leaves at the top of the plant, which necessitated the removal of the entire crop. Adjacent to this greenhouse were other larger houses, which, however, were planted somewhat later, and the plants in these houses entirely escaped infection.

Bacteriosis of cucumbers has been rare, if it has occurred at all, under glass in this State. A few years ago we secured germs from an affected out-door crop of cucumbers, and inoculated the soil in our greenhouse in which cucumbers were growing, with the result that not the slightest infection occurred in any instance. The experiment was made during the fall and winter months, which may account in part for the failure of the germs to infect the plants.

There is always risk in planting a cucumber house in August, since the downy mildew previously mentioned, and Anthracnose (*Colletotrichum Lagenarium* (Pass.) Ell. & Hals.), are sure to be present during August in full force; and the same probably is true to a certain extent in regard to the germs of bacteriosis. At any rate, it is a significant fact that nearly every house planted late has none of these troubles to contend with.

In the case of the bacteriosis described above we are of the opinion that the method of growing the crop had something to do with its susceptibility to infection, since the plants were in our estimation somewhat too vigorous growers, and did not possess the best texture.

We have frequently advised growers of cucumbers not to plant in August, on account of mildews, etc. There is much

less risk in planting in September, and scarcely any during any time in October. If a house of cucumbers is planted in August, it is necessary to ventilate freely, apply little or no water to the foliage, and keep down the moisture in the atmosphere to the lowest degree, in order to hold mildews and Anthracnose in check.

Bacterial Disease of Lettuce.

Our attention has been called at different times to an undescribed bacterial disease of lettuce, which is reported as causing considerable damage in some localities. This disease has been observed in our greenhouse for many years, and during the year 1901 Mr. Percival C. Brooks, then a member of the senior class in botany, investigated this problem. He succeeded in isolating an organism from a diseased lettuce plant, and obtained positive results from his inoculation experiments with healthy plants.

The disease in question has never been observed by us in this State except in our own house, notwithstanding the fact that we have for many years had occasion to carefully study the various lettuce crops in the State, and have constantly been on the lookout for it. Neither has careful inquiry brought to light any trace of a similar affection in lettuce houses in Massachusetts. Since the disease occurred in our lettuce house on crops which had been forced too rapidly, it was considered of little consequence and was given scarcely any attention, inasmuch as we thought the trouble arose from improper management of the crop. Our only purpose in calling attention to this disease at the present time is that it is reported as doing considerable damage elsewhere, particularly in the south, which makes it desirable that we should be on the lookout for it. The disease results in the appearance of numerous small brownish spots about the size of a pin-head on the young and tender light-colored leaves of the head. The spots are frequently quite numerous, and in some cases run together, causing a destruction of a portion of the leaves of the head. No attempt was made by Mr. Brooks to make any extensive study of the organisms causing the disease, since at that time it was believed to be of little consequence, and only

an accompaniment of too rapid forcing. In some localities, particularly farther south, we hear different reports concerning its prevalence.

Bacteriosis of Geraniums.

In a previous publication of this station a short note was made of a bacterial disease of geraniums occurring in this State.[1] Since that time we have made yearly observations on the prevalence of this disease in various sections. It has appeared every year since it was first noted here in 1898, and has also been reported from various other sections of the United States within recent years.

Our observations have shown that it has frequently been abundant and generally distributed, so much so at times that gardeners have been more or less concerned about it. We have also noticed this disease in greenhouses each year, it having apparently been brought in with out-door stock, although it does not appear to be serious under glass. Our observations have shown that the trouble is more frequently found on plants exposed to bright sunshine than on those growing in shade, and is evidently more severe farther south, where the light is more intense than in Massachusetts. Geraniums require comparatively little light for their best development, and a strong light may favor the development of this disease.

The disease affects the leaves, causing spots to appear on them. The spots are often numerous and sometimes coalesce, which causes the diseased portions to dry up and turn brown. The spots are about one-eighth of an inch in diameter, and resemble blisters. No other portion of the plant is affected. Examination of a large number of diseased sections shows only a few bacteria present in the tissues except in those cells bordering on the outer portions of the spots.

The geranium is a very hardy plant, and one of the freest from disease. No attempt has been made to treat this disease, to our knowledge, and should it become more troublesome some remedy for it will have to be discovered.

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[1] Tenth annual report, Hatch Experiment Station, 1898, page 67.

Tobacco Troubles.

Some troubles, due to methods of handling the crop, occasionally occur on tobacco growing in the Connecticut valley. Instances have been known for years where the crops have been set back by the use of certain fertilizers and methods of applying them. Tobacco, corn and other crops, moreover, show a tendency to stand still or make little growth on soil in which there is an overabundance of moisture.

Our attention has been called to a tobacco trouble which appears to be caused by the use of fertilizer. In one particular field which we examined the roots of the plants had all the characteristic symptoms of fertilizer burning, and careful examination failed to reveal any fungi associated with this trouble. The tap roots of all the plants which we examined had been destroyed, and new secondary roots had developed freely on the injured end of the tap root. These were endeavoring to penetrate to the lower strata of the soil, and would in turn become burned on the tip before reaching any great distance.

The effect on the crop manifested itself in a stunted growth, the plants remaining in this condition for weeks. When plants affected with this trouble were removed to other soils they would in all cases make rapid growth. Even in the field where the trouble occurred they would reach a fair degree of maturity at the time of harvesting. There appears to be absolutely no connection between this trouble and the seed bed, since other fields close by were planted from this seed bed, and not the slightest evidence of the trouble was to be seen. Moreover, it occurs on new tobacco land as well as on old. It was as severe on land which had been planted this year for the first time as it was on old land.

The trouble apparently seems to have no inclination to spread, since a field only ten or twelve feet away from the infected one, planted with seedlings from the same seed bed, showed no trace of it. It is much more conspicuous in low places which receive drainage from the surrounding soil than on the drier knolls.

At present, at any rate, the trouble must be attributed to

mistakes in fertilizing, since no fungi are associated with it; and the only difference between the cultivation of this particular crop in which the trouble occurred and other surrounding ones, some of which had been planted from the same seed beds, consisted in the methods of fertilizing.

Monilia on Peach Stem.

For a number of years we have received peach twigs in this department which have been conspicuously spotted. The spots appear on one-year-old wood, and are of an ash or greyish color in the center, with a more highly colored, generally purple margin. Examination of these spots has invariably revealed the presence of a species of Monilia which extends scarcely below the epidermis. Occasionally the spores of Cladosporium are to be found, but by no means frequently. Some years the spotting appears to be much more common than others, and there is generally little difficulty in finding it in orchards during such periods. Cultures from the spots have always produced Monilia. Mr. F. A. Bartlett, now of Hampton Institute, Hampton, Va., and formerly a senior in our laboratory, during the year 1905 made many isolations and cultures of this fungus. He was not able to complete his studies of the fungus, but from his observations it would appear that a species of Monilia was the sole cause of this spotting. Mr. Bartlett thus verified observations which had been previously made by my former assistant, Prof. R. E. Smith, and myself. From Mr. Bartlett's various cultures it would appear that the spores of Monilia causing this spotting to peach twigs are not the same as those occurring on the fruit (*Oidium fructigenum*)[1] but is a different species, possessing smaller spores, and otherwise differing from the species attacking the fruit of the peach, etc.

There are various Monilia and Cladosporium troubles which affect the peach described in experiment station publications and foreign pathological journals, all of which appear to differ from this one in its effect upon twigs.

We hope to make further investigations of this trouble, and in the meanwhile it may be mentioned that where the lime

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[1] *Oidium fructigenum*, Kze. & Schm.

and sulfur treatment has been applied to peach trees for the San José scale not the slightest trace of this spotting can be found, showing that this mixture has a very repressive influence upon the fungus.

The Lime and Sulfur Mixture as a Fungicide.

The increased activity of the San José scale during the past two years has resulted in more attention being paid to the spraying of orchards. This has been the means of reducing very perceptibly many of the troubles to which orchards are subject. Our examinations of a number of orchards during the past summer which had been sprayed with the lime and sulfur mixture have convinced us that this mixture is one of the most reliable fungicides known for the suppression of certain fungous diseases. It is especially applicable for the control of such diseases as the peach leaf curl, as has been previously pointed out by many observers. It is equally valuable in the treatment of Monilia and Cladosporium, which occasionally attack the stem.

The large and exceedingly well-cared-for orchard of Mr. Elbert Bliss of Wilbraham offers one of the best examples of the efficiency of the San José mixture as a fungicide. His orchard, which covers many acres, was absolutely free from any blemish due to fungi, both as regards foliage and wood. The college orchard, which was sprayed for the San José scale with the lime and sulfur mixture, has been remarkably free from fungous troubles during the past season. Our observations of other orchards have seemed to indicate that spraying with the lime and sulfur mixture succeeds in controlling to some extent canker, pear blight, black knot and other diseases. We have frequently advocated early spring spraying of trees before the leaves appear, with a solution of copper sulfate at the rate of 1 pound to 50 gallons of water, as we maintain that many of the common blights are more successfully prevented by this spraying than by later ones. It has been shown that early spraying with copper sulfate has been successful in holding in check the black knot of the plum.

The San José scale may prove in more than one way a "blessing in disguise."

Potato Spraying Experiments.

A large field of potatoes on the college farm was used for experiments in spraying the past season. The field was located on the west slope near the farm barn, and included seven acres. The following varieties were planted: Early Harvest, Early Michigan, Carmen Number Three, Green Mountain and Delaware. These were planted in rows running lengthwise of the field. The experiment was carefully planned as regards varieties, conditions of the soil, etc., and running parallel to each of the various treated rows were left untreated ones for the purpose of comparison.

As there was some delay in obtaining the spraying mixtures, the whole field, including the checked plants, was sprayed once with Paris green for the potato beetle. In subsequent sprayings the following mixtures were used: wet Bordeaux containing Paris green, dry Bordeaux, copper phosphate and a mixture termed "1—2—3." The wet Bordeaux was made according to the standard formula (4—4—50). The other mixtures were proprietary substances, and were furnished by the Bowker Insecticide Company, which to our personal knowledge has always taken great pains to place on the market only the most reliable fungicides and insecticides. The "1—2—3" contained compounds of copper, arsenic and lime. The dates of the three applications were July 3, 7, and 12, no spraying being done after the latter date, on account of the luxuriant growth of the tops, which prevented access to the field without damage to the crop. The copper phosphate, dry Bordeaux and "1—2—3" are all dust sprays, and were applied early in the morning with a dust sprayer, when dew covered the foliage. The effects of spraying on this crop were carefully observed by various members of the station staff, together with Mr. Forristall, who supervised all the work, and made most careful observations as to the effects of the different sprays.

At the close of the experiments corresponding rows of the treated and untreated plants were dug, the potatoes carefully weighed by Mr. Forristall, and the results tabulated. The yields given by the various treatments are as follows: —

Average Yield of Sprayed Potatoes.

Treatment.	Average Yield (Pounds).
Wet Bordeaux,	55.98
Dry Bordeaux,	58.11
Copper phosphate,	52.34
"1—2—3,"	55.88
Untreated,	55.46

These results show no differences in the yield which can be ascribed to spraying. Observations on the condition of the crop during the summer did not show any material differences except in the case of the wet Bordeaux treatment, which was perceptibly superior in all respects to the others, at least during the greater part of the season. The plants treated with wet Bordeaux possessed the darkest-colored foliage, and were by far the most free from the flea beetle. The season was remarkably free from potato blights, the only thing occurring of any consequence being the flea beetle; and, with the exception of the wet Bordeaux, which contained Paris green, there appeared to be little or no difference between the treated rows and those untreated. At the time the potatoes were dug there was no perceptible difference to be observed between any of the rows. Owing to the season's comparative freedom from blight, little or no value can be placed upon these experiments.

The ease with which dust sprays can be applied makes the process of spraying less tedious, and a dust spray which possesses the merits of other reliable sprays on the market would be gladly received. However, careful tests of the relative merits of the wet and dry sprays indicate that the wet Bordeaux is superior in all cases to the dry.

Our potato growers should realize that the conditions in this State are entirely different from those in Vermont and Maine, and the spraying calendar recommended for those States is unsuited to our conditions, since their spraying is largely devoted to the control of the late blight, which is not generally severe here. On the other hand, it is the early blight, according to our experience, which does the most dam-

age in Massachusetts; and in order to prevent attacks from this, farmers should commence to spray when the potatoes are not more than one-fourth grown, which would ordinarily be about the 20th of June. Much of the injury to potatoes is due to the flea beetle, which affects them in a manner similar to the early blight.

We believe that a first spraying of potatoes should be made with Bordeaux and "Disparene," instead of Paris green, since "Disparene" is a reliable insecticide, while Paris green is not, at the present time.

Copper Sulfate Treatment of Stagnant Water.

In a previous report we gave the results of a copper sulfate treatment of the college pond.[1] This pond is located on the college grounds, and contains about 8,000,000 gallons of water; it is quite shallow and has a muddy bottom. The amount of water which it receives during the summer months is not sufficient to cause a very constant overflow, and partly for this reason it occasionally becomes stagnant. There is also some pollution from cesspools which drain into it, and during freshets considerable amounts of fine sand, silt and clay are carried into the pond. Much of this silt, etc., remains in suspension for a long time, giving the water a yellowish tinge and roily appearance. Evaporation tests show that the water contains 45.6 parts sediment to 10,000 parts of water. During June the water usually has a disagreeable odor and becomes quite obnoxious. This odor is similar to that which rises from frog ponds where considerable decomposition takes place, and at other times it has the odor which is characterized as "fishy."

The pond has frequently been drained, which is responsible for stimulating growths of algæ, particularly Spirogyra, and for the past few years Anabæna has been present in greater or less amounts. It should be stated at the outset that our object in treating the pond was not to clear up points of controversy in connection with the copper sulfate method of treatment; it was done largely to obviate a nuisance.

That copper sulfate has an effect upon algæ has been known

[1] Eighteenth annual report, Hatch Experiment Station, 1906, pages 143–146.

to physiologists for many years; but the treatment of large volumes of water with this chemical is, so far as we know, comparatively recent. Those who wish to become familiar with the more technical features of this subject are referred to the older literature, much of which is in German, and to the more recent publications of the United States Department of Agriculture and our own State Board of Health.

The treatment given during 1906 was similar to that of 1905, and consisted in applying 1 part of copper sulfate to 4,000,000 of water. The copper sulfate was placed in a coarse bag attached to a canoe, which followed concentric circles over the pond until the copper sulfate was all dissolved. Samples of water were taken daily for bacterial examination a few days before treatment and each day after until July 19, when the experiment was discontinued. The usual bacterial methods were employed, with the following results: —

Table showing the Results of treating the College Pond with Copper Sulfate at the Rate of 1 Part of Copper Sulfate to 4,000,000 of Water. (Treated June 14, 1906.)

[Number of bacteria per c. c. of water.]

June 10,	7,005[1]	June 26,	846
11,	6,034[1]	27,	1,085
12,	5,757[1]	28,	1,231
13,	7,188[1]	29,	1,265
14,	7,158[1]	30,	1,006
14,	130[2]	July 1,	1,365
14,	56[3]	2,	1,231
15,	142[4]	3,	1,308
16,	156	4,	1,231
17,	156	5,	1,006
18,	341	7,	1,084
19,	554	9,	1,000
20,	769	11,	1,208
21,	1,000	13,	1,208
22,	1,000	15,	1,275
23,	756	17,	1,462
24,	768	19,	1,770
25,	927		

[1] Before treatment.
[2] One hour after treatment.
[3] Two hours after treatment.
[4] Twenty-four hours after treatment.

The number of bacteria per cubic centimeter showed a decided falling off after the treatment, but subsequently an increase was noticed, although the number did not equal that present before treatment. The first bacterial examination of the water occurred one and two hours respectively after treatment, at which time there was noted considerable decrease in the number of organisms. It seems hardly creditable, however, that the copper could have been sufficiently diffused in the pond to cause such a rapid decrease in the number of the bacteria in so short a time. Some Anabæna were present in the pond previous to treatment, but none was observed directly afterwards; neither were any Spirogyra noted either before or after treatment. On the other hand, there were various forms of life, such as Daphnia, etc., present, both before and after treatment. No chemical analyses of the water were attempted, since the ordinary methods of analysis are not especially valuable in detecting slight traces of copper in water. It would appear from the culture of seedlings in glass vessels containing water and sand in which copper is present, and from the results of chemical analyses of the mud in the bottom of the reservoir, that a large amount of copper is taken up by this mud. The results of copper treatment of the pond in 1905 and 1906 show that the bacteria never regained their former numbers.

In a pond like this one, which is more or less polluted from cesspools, one would naturally infer that bacteria would increase rapidly after a few days. During August the pond was in an even worse condition than in June, as a large number of dead fish, termed "suckers," which had died from some unknown cause, were floating on the surface. Again during October there was a fairly luxuriant growth of Anabæna present for a few days, but this disappeared quickly, presumably on account of the rather cold nights which occurred at that time.

At the time the treatment was under way, parallel laboratory tests were made. For this purpose we employed 18 liters of water from the college pond in two rectangular jars, there being 9 liters in each jar, one of which was treated with copper sulfate at the rate of 1 part of the sulfate to 4,000,000

of water, while the other jar was left untreated. The jars were placed side by side in the laboratory, and exposed to the organisms of the air. The water was taken from the pond previous to its being treated. The results of the experiments are shown in the following table: —

Table showing the Results of treating Pond Water with Copper Sulfate at the Rate of 1 Part of Copper Sulfate to 4,000,000 of Water. (Experiment made in Laboratory, in Glass Aquaria Jars.)

[Number of bacteria per c. c. of water.]

Date.	Pond Water untreated.	Pond Water treated.
June 14,	7,158	30[1]
15,	5,723	15
16,	4,849	38
17,	4,849	32
18,	4,444	24
19,	6,188	31
20,	7,927	43
21,	6,112	59
22,	4,772	101
23,	6,362	120
24,	5,313	54
25,	6,273	134
26,	7,004	126
27,	6,927	98
28,	8,282	170
29,	8,926	242
30,	6,419	310
July 1,	7,004	270
2,	7,409	298
3,	8,107	340
4,	6,792	930
5,	7,972	872
7,	10,168	800
9,	6,412	1,060
11,	6,989	1,000
13,	7,399	940
15,	6,034	946
17,	8,632	1,390
19,	10,656	1,240

[1] One hour after treatment.

The results shown in this experiment coincide in a general way with those of the previous one. They are, however, of more value, since they show the bacterial flora of the normal or untreated pond water.

It will be noted that the number of bacteria in the untreated pond water remained quite constant throughout the experiment, while the water treated with copper sulfate showed the same general decrease in the number of bacteria. The subsequent increase in the number of bacteria in the treated water in the laboratory experiment was smaller than that shown by the pond experiment. Furthermore, a comparison of the two jars in the laboratory experiments showed that the water in the treated jar was much clearer, owing to the fact that most of the forms of living matter had been killed and had settled to the bottom of the jar. This was proved by the much larger amount of sediment in the bottom of the treated jar than in the untreated.

Large bodies of water can be successfully treated with copper sulfate, and many undesirable forms of organisms eliminated. The copper sulfate treatment, moreover, appears to exert an influence upon the bacterial flora for quite a length of time; but after a certain period has elapsed a body of water may become as badly contaminated with various forms of living matter as before, or even worse.

The location of the college pond is such that no harm could result in any way from a treatment with copper sulfate, even though some of the copper escaped. Precautions, however, must be exercised in treating bodies of water; and the safest method to follow, in case such treatment is necessary, would be to consult our State Board of Health or others familiar with this subject.

Banding Substances for Trees.

In connection with the renewed warfare against the gypsy and brown-tail moths, a number of new banding substances, which are claimed to be effectual as insect barriers and harmless to trees, have been placed on the market within a year or so. These substances are sold under various names and at varying prices, and they are quite dissimilar in their chemical

composition and in the effects produced on trees. Any substance which is likely to cause even the slightest injury when applied to trees should not be employed, and when such substances actually cause the death of trees, it becomes a gross offence to apply them to public shade trees.

At the request of William B. de las Casas, Esq., chairman of the Metropolitan Park Commission, the writer made an examination during the summer of 1905 of a large number of trees located in Middlesex Fells and other districts around Boston, with a view to determining the effects of the various so-called banding substances on trees.

In addition to our numerous examinations of the effects of these various substances on trees, we have tested a great many in a critical way on small plants. Our conclusions relating to the effects of the substances are based upon a larger number of observations, together with numerous tests on stems, leaves, etc., of a variety of herbaceous plants. Any substance which causes injury to herbaceous plants may also produce the same effect on trees, although the time necessary to produce injury to herbaceous plants is brief compared to that necessary to give rise to corresponding results in a tree.

A good banding substance should not cause the slightest injury to trees, or even to tender tissues. It should not harden at low temperature, neither should it melt at comparatively high temperature. It should be inconspicuous when applied to the tree, and easily put on and removed, and should remain sticky during the entire season.

Tanglefoot. — This material is now extensively used, and is a semi-transparent, sticky substance, not affected by low temperature (32° F.) or by temperatures under 125° or 130° F. Its principal bases are probably castor oil, resin and wax, which are substances harmless to vegetable tissue; and, whatever the other constituents of this banding substance may be, they do not render it harmful to trees. Tanglefoot applied to a large number of plants possessing a thin epidermis has never caused any injury. In short, this is the only substance which we have met which stands all the tests a perfectly harmless banding material should when applied directly to plant tissue.

Bodlime. — This is the proprietary name of a substance resembling Raupenleim, a European product, and both have been on the market for some years. Bodlime is an American preparation, and has been used extensively for some time. The directions which are furnished with Bodlime advise first putting a band of tarred or sheathing paper eight inches wide on young or thin-bark trees, and then applying Bodlime to the band. Over 90 per cent., however, of the trees examined by us last summer on which Bodlime had been applied were those of the smooth-bark type, ranging from two inches to two feet in diameter, and in no instances were tarred or sheathing paper bands applied. In practically all cases this substance had penetrated the bark and injured the cambium layer. This injury, however, is in all probability not sufficient to kill the trees in every case; but more or less prominent effects will be left on the trees for some years, as evidence of the injury due to Bodlime. Some specimens of trees six inches in diameter were pointed out which were killed with Bodlime; and practically all the Carolina poplars located on the Fellsway, Malden, which have been treated with this substance, showed much injury to the cambium layer, resulting in prominent swellings on the trees where this substance had been applied.

A number of small white maples (two or three inches in diameter), which had been treated with Bodlime, appeared in two or three weeks to have an abnormal cambium layer, due to the penetration of the substance to the vital tissue. In all these cases Bodlime was applied directly to the trees, without paper bands. It should be noted, however, *that the manufacturers never intended that it should be applied to small or smooth-bark trees without first banding with tarred or sheathing paper, and the directions specifically state this.* When this is applied to large trees, however, without paper banding, it generally causes some subsequent slight disfiguration of the tree. We believe, however, that Bodlime constitutes a reliable banding substance, and can be applied to trees if the directions of the manufacturers are followed, — to first put on a band of tarred or sheathing paper. It should by no means be considered a reflection on the manufacturers

if people will persist in ignoring the proper directions for applying the substance, as there is scarcely a remedy on the market which will not produce injurious effects if used injudiciously.

Anti-Moth. — This substance was used considerably in the summer of 1905 as a tree-banding material. It is a dark-colored, pasty substance, suggestive of wheel grease, and is applied directly to the bark. There were many instances observed where it was causing injury by soaking through the large, thick, rough-bark trees, as well as small, thin-bark ones. The trees which came under our notice had been treated only a few weeks with this substance, but our observations were sufficient to show that this constitutes a dangerous substance to apply directly to the bark of trees. Various small herbaceous plants banded with Anti-Moth died in a few days.

Eureka Tree Paste. — This substance as a banding material is not so universally employed as those previously mentioned, therefore our observations were limited in regard to its effects on trees. Moreover, this material, at the time our observations were made, had been on trees for only a brief period of time, consequently, the ultimate effects on the trees have not been observed by us. This substance resembles Anti-Moth, and is applied in the same manner. From the nature of the material, and its effects upon the stems of herbaceous plants, it cannot be recommended as a safe banding substance. Our experiments on herbaceous plants show that it is equally as injurious as the substance previously mentioned.

Raupenleim and Dendrolene. — These have been used as banding materials, although we have seen no authentic instances where they have been applied to trees in the vicinity of Boston during the past year. Raupenleim is a well-known German banding material, and Bodlime is supposed to be in many respects similar to it. Both, as far as we can learn, have about the same effects on vegetable tissue; that is, they injure it. Raupenleim was previously used by the Gypsy Moth Commission in large quantities. Dendrolene is an American product, apparently similar to Raupenleim in every way, both being crude petroleum products.

Razzle Dazzle. — During the past year our attention has

been called to the use of a banding substance termed Razzle Dazzle, which has been employed to some extent on trees. This substance was sent in to us from one of the towns in the vicinity of Boston, with the report that it was doing damage to trees. We made a test of the substance on various herbaceous plants, and found that it killed them in a very short time. The substance appears to be made of resin, castor oil and some other oil-like petroleum which is injurious to vegetable tissue. We found that Razzle Dazzle has altogether too low a melting point. It commenced to run at about 90° F., and flowed freely at 100° F.

Bug Stop. — This substance is apparently made out of resin, oil and some form of grease, which causes injury to vegetable tissue. We found on testing this that it was very similar in its effects on tissue to Razzle Dazzle, and has a melting point ranging from 79° to 94° F. Besides the injurious effects which it has on vegetable tissue, it has a melting point entirely too low to make it a desirable banding substance.

Printer's Ink and Tarred Paper. — Printer's ink applied to tarred paper has been used to some extent for many years as a banding substance, and no ill results arising from its use have met our observation. We find this substance used extensively in the city of Medford on General Lawrence's estate.

Other Injurious Substances. — In one of the cities in the neighborhood of Boston crude petroleum or gas oil, such as is used in the manufacture of water gas, has been extensively used in spraying the trunks of trees for the purpose of killing gypsy moth eggs. This substance penetrates the bark very readily, and kills the vital layer. There are numerous instances where trees have been completely girdled, and have died in a very short time from the use of this substance.

Gas oil and creosote are used extensively for treating gypsy moth nests, and when mixed with lampblack they appear to cause little or no injury. Both of these substances are capable of causing injury to plants, either when used alone or when mixed with lampblack. We have not discovered any injury to trees from the use of these substances, however, when mixed with lampblack and used as a paint for the treatment of gypsy

moth egg clusters. In one instance, where creosote and naphtha were applied with an atomizer to the trunks of trees covered with gypsy caterpillars, at the rate of 1 part of creosote and 5 parts of naphtha, the bark was rendered brittle and lifeless. At the time our examinations were made on these trees no injury had occurred to the cambium layer, but we should suspect that injury would later follow this method of treatment.

Some injury to trees often occurs from the use of kerosene, or kerosene and water together, when applied to the bark of trees. Kerosene and water have occasionally been applied to tree trunks for various insect pests by the aid of a certain mechanical mixing device. It should be stated, however, that these mechanical mixers are unreliable, and it is never safe to apply kerosene to trees, not even when mixed with water. The use of a gasoline blower or torch for the purpose of killing caterpillars has been in vogue to some extent. This should be condemned, since some injury has resulted from this practice. Scraping the bark too closely previous to applying a banding substance should be guarded against.

In conclusion, it may be said that Tanglefoot appears to be the only banding substance which we have tested that does not in any way cause injury to plant tissue, and that can be safely applied directly to tree trunks. Since this substance has a tendency to run at about 125° to 130° F., a slightly higher melting point would improve it. The manufacturers test this substance at 126° F., on a smooth, vertical surface, claiming that it will not run below that temperature; also, that some of their samples will not run below 130° F. They state that it will stand a little higher temperature on the bark of trees before it begins to run. Unfortunately, much of the Tanglefoot sent out by the manufacturers last spring was made on a different formula, and the melting point was entirely too low. It was sent back to the manufacturers, and modified according to a previous formula.

Such material as printer's ink, Bodlime, etc., can be safely applied to tree trunks in connection with tarred paper; and the latter can also be applied to rough, thick-bark trees without killing them, although even when used in this manner it will

often produce some injury, which, however, may not prove fatal. We believe that it is essential, in applying any substance to a tree as a means of protecting it against insects, that one should be well within the limit of safety.

In this connection it should be noted that all of the manufacturers of these substances are, so far as we have learned, honorable business men, as is shown by their perfect frankness, and desire not to place any substance on the market which is not reliable. However, one should be cautious in purchasing newly advertised banding materials, since we have reason to believe that some of these new mixtures will not prove reliable. We have had opportunities to test a large number of new mixtures during the past two years, none of which, in our estimation, answers the requirements of a good, reliable banding substance.

Effects of Escaping Illuminating Gas on Trees.

Undoubtedly a larger number of trees suffer from the effects of escaping illuminating gas at the present time than in previous years. The increased death rate from this cause may be accounted for by the fact that gas is now more extensively used than formerly, and the larger pipes now in use, together with modifications in the methods of laying these pipes and calking, may be in part responsible for the increased leakage. At any rate, it would seem that where small pipes have been in the ground for many years with thread joint connections there is much less leakage than where larger pipes are used, and where the calking is done with Portland or Roman cement and oakum or lead.

There is a large amount of gas manufactured by companies which is unaccounted for. According to the twenty-first annual report of the Gas and Electric Light Commissioners of Massachusetts, the production of gas for the year 1905 in this State was 6,418,024,954 cubic feet. The amount unaccounted for during that year was 622,304,044 cubic feet; in other words, there was a loss of about 10 per cent. Probably this loss represents more than mere leakage, since part of it may be accounted for by differences in temperature which the gases are subjected to when measured. Nevertheless, there

is a very large number of leaks in gas mains at the present time, and the number of cubic feet of gas which annually escape into the soil is quite large.

There are a great many joints in gas mains from which can be detected only slight leakage, — perhaps from two to three cubic feet a day; whereas there are others from which the leakage is very extensive, and from which thousands of cubic feet of gas escape into the soil in the course of a year. Even these smaller leaks, where the outflow is only from two to three cubic feet a day, are capable of injuring trees in the course of time, since the soil becomes charged with gas to quite an extent in a few years. Should the roots of trees happen to be near these leaks, the trees will become unhealthy, but perhaps will not die. There are hundreds of city trees affected in this manner, and gas is seldom suspected of causing their sickly condition. In the eastern States, at least, there are three kinds of gas used, — water gas, coal gas and oil gas. So far as the effects of these various gases on trees are concerned, there is apparently little or no difference, since they all contain similar elements which are poisonous to trees.

There are two classes of injury which may readily be distinguished as resulting from gas poisoning: first, incipient cases; and second, pronounced cases. In the first series we have those already alluded to as resulting from small leaks, and the ground in such cases never becomes fully charged for any considerable distance. They may not result in killing the tree directly, but cause it to be unhealthy, and there is likely to be a large amount of dead wood found on such trees annually. Occasionally a large tree may be located near a small leakage, and in such a case only a single root will be affected. Those portions of the trunk of the tree in direct connection with the leak will, however, show the effects of gas poisoning. Small leaks of this description often produce only local injury. Trees affected in this manner may suffer with what is termed "general debility," — a term often used to cover up a vast amount of ignorance concerning diseases in general. In severe cases of gas poisoning, such as take place where there is a large leak, the effects on a tree are very pronounced, and there is absolutely no hope of recovery for a

Showing effect of illuminating gas on elm tree, one and one-half years after leakage occurred. (From "Park and Cemetery.")

tree which has once been severely injured by gas; in short, where a tree has been defoliated or even half defoliated from the effects of gas, there is no hope for it, although it might be possible, if one could dig up all the soil around it and expose it to the air, to eliminate much of the gas in the soil, in which case the tree might make some attempt to recover.

The characteristic symptoms of gas poisoning are quite marked to one familiar with them, and can generally be distinguished from other kinds of injury which are likely to affect a tree. It requires, however, pretty close observation and thorough understanding of conditions in order to distinguish gas poisoning from some other types of injury which may occur. For example, in the gypsy moth district about Boston the trunks of many trees have been treated with crude oil and various other substances which are exceedingly injurious to trees. Crude oil or kerosene, when sprayed on the bark of a tree, will penetrate the wood to some extent. Unless one is perfectly familiar with the characteristic symptoms of trees poisoned with gas, it would be a very easy matter to confound these two classes of injuries. In both cases the bark becomes loose and falls off the tree very quickly. From careful observations of the trunks of trees, however, the effects of crude oil can generally be distinguished from those caused by gas, by one who is familiar with these characteristic injuries.

In general, however, the symptoms shown by trees affected with illuminating gas are quite different from those arising from other causes which are likely to be active. Trees affected with gas are very susceptible to rapid disintegration. One of the first effects of poisoning in summer would be a yellowing and drying up of the foliage, and a greater or less defoliation of the tree, according to the degree of poisoning. The trunk of the tree is generally dark colored, indicating an absence of life; but this feature is not always present.

The occurrence of various species of fungi on trees affected by gas is rather conspicuous, since these fungi are often very numerous, and make their appearance soon after a tree has been injured; whereas on trees dying from other causes it is sometimes many years before the bark becomes covered with fungi. The sap wood is often found to be discolored, and it

has peculiar, characteristic odors which assist in a diagnosis. Sometimes, however, especially when the tree is injured by gas in late summer, at which time the flow of sap is not so pronounced as in the spring, the odors of the wood are not so marked.

The writer has had many years' experience in examining trees injured by illuminating gas, and has had occasion to study a large number of them each year. In our diagnosis of such trees we make use of a small hatchet, which is employed to cut into the trunk of a tree for the purpose of examining the tissue. In most cases it is only necessary to insert the hatchet into the trunk and gradually pull the tissue back to see whether it is normal or abnormal. Little injury is done to the tree by this practice, as a mere slit in a healthy tree will heal over in a short time. In other cases it is necessary to take out a chip and examine the tissues under a microscope. An examination, by means of a hatchet, of the larger roots which extend above the surface of the soil, causes less disfigurement, and the source of leakage, if such is present, may be discovered. The escape of gas into the soil from a leak follows the line of least resistance. For this reason, if leakage occurs in the street in front of a house one can usually detect the odor of gas in the cellar, as the gas will follow the exterior of the pipe leading into the cellar.

There is considerable difference in the resistance of soils to gas. In gravelly soils we have known gas to travel 2,000 feet without any difficulty when the ground is frozen, and escape into the cellar of a house; whereas in heavier soils gas is more likely to be restricted to smaller areas.

The poisonous properties of gas undoubtedly consist in the coal tar products, which contain such compounds as sulfates, cyanides, etc. Gas escaping into the soil probably condenses fully as rapidly as in the pipe. The gas-drip which is taken out of a pipe is the condensed portion, and this in itself is very rank in odor and extremely injurious to plants, whether the volatile products are taken in through the leaves or the liquid through the roots. It is apparently these condensed products which are taken up by the roots and which poison the tree. About 1 or 2 per cent. of gas is absorbed by water, and

Large elms killed by escaping illuminating gas, one and one-half years after leakage occurred. (From "Park and Cemetery.")

the water in the soil becomes charged to a certain extent with gas. In the course of time, where the leakage is more or less extensive, the odor of the soil becomes extremely obnoxious. This odor disappears very quickly when the soil is aerated; in fact, when a gas leak is found it is an excellent idea to leave the ditch open for a few days, to get rid of the strong odors which are present in the soil. There is a certain capacity of adaptation of plants to poisons, and this probably exists to some extent in the case of trees; but this capacity is limited, and where the leakage of gas is continuous, the roots are sure to be poisoned in time. The writer has treated various small trees and plants with gas, and has grown plants in water charged with it. Gas, like many other poisons, acts as a stimulus to plants at first, but eventually kills them. It is possible, however, to keep roots alive in water charged with gas every twenty-four hours for a considerable length of time. Finally, however, after the plant has absorbed a certain amount the cambium layer is affected, and disintegration takes place rapidly. It requires a considerable amount of gas to kill a large tree, but it must be borne in mind that the conditions surrounding a tree are favorable for maintaining gas in the soil for a long time. Mr. H. A. Ballou, one of our former students, treated a large maple tree with 1,000 cubic feet of gas. This was done by digging a hole in the ground under the feeding roots to a depth of four feet or more, and the gas was allowed to escape into the soil at this point for a number of months. The result was that not the slightest injury was done to the tree. If, however, the same amount of gas had been allowed to escape near a tree located on a macadamized road, and the leakage had extended over a period of two years instead of three or four months, some injury would have been discernible.

Many gas companies now openly recognize the fact that a certain amount of gas leakage occurs continually, and that a certain number of trees are likely to be killed each year; therefore, they endeavor to settle all claims for damages to trees arising from gas out of the courts. In Massachusetts the court has decided in more than one instance that a good-sized, well-developed and sound tree in front of an estate

is worth from $150 or $200 in the valuation of that property; and if such a tree is killed by gas, the abutter is entitled to damages. In most of the cases of gas poisoning the companies have settled with the abutters, allowing anywhere from $5 to $150 a tree. In other States courts have decided that an owner of land which abuts on a city street and which is planted with shade trees is entitled to have such trees protected against negligence or wilful destruction at the hands of a third party. A large, handsome tree taken from a well-kept avenue is a greater loss to the abutter's property than a similar tree on a poor, ill-kept street. Moreover, a tree half-killed by the teeth of horses is not worth as much as one in good condition. In some cities gas companies have settled with the city for the loss of trees.

According to tree laws in Massachusetts, gas companies are undoubtedly subject to a fine for injuring or causing the death of a tree, in addition to the damages for causing a deterioration of property owing to the loss of such trees, since the laws relating to injuries to shade trees are explicit. In some cases the abutter is satisfied if new trees are planted to replace the old ones.

Undoubtedly much of the loss arising from gas the past few years has been due to inferior work in laying pipes. In one small city, where four miles of pipe were laid, we were able to find one hundred trees which were injured beyond recovery from gas poisoning, two years after the gas mains were laid; and we venture to say that three or four hundred other trees in the same locality were more or less affected by gas, many of which will subsequently die a premature death.

Germination and Growth in Soils of Different Texture.

It requires only a casual glance at the flora of any region to note the fact that soil texture plays an important part in the distribution and adaptation of plants. Soil, however, is so intimately connected with and modified by other factors, such as organic matter, arrangement of the particles of the soil, chemical constituents, the presence of living organisms and differences in the amount of water, that it is a most diffi-

cult problem to determine accurately the role which texture alone plays in plant distribution and adaptation.

Humus is undoubtedly closely associated with certain ecological features connected with the life history of plants, since it furnishes an environment for various micro-organisms which in some instances amount to many millions per gram; and if the behavior of these organisms in culture media furnishes a criterion for their activity in soil, important chemical changes must take place.

In endeavoring to account for the distribution of any particular species of plant, one is confronted with a complex problem, since there are various influences responsible for distribution, and the elimination of these factors is beset with difficulties.

In some cases differences in the degree of adaptability of plants appear to exist corresponding with their stages of development; for example, a seedling will die in a soil of certain texture, when a more mature plant of the same species will succeed in thriving to a greater or less extent.

Soil texture exerts an influence upon the configuration of plants which may be seen even in restricted areas; for example, certain soils are especially adapted to the luxuriant development of elms, and such soils exert a marked influence not only upon the general type of tree, but the color, size and texture of the leaves, — a feature which may be seen to a similar degree in other native plants.

Among our well-known cultivated plants there are some which are influenced to quite an extent by soil texture, the best known among these being tobacco. Since the texture, aroma and color of the leaf is tested many thousand times daily by smokers, much knowledge has been gained regarding the influence of soil texture and other factors upon the growth of this crop. It is well known that the crops from some soils sell for two and three times as much as those grown on soils of a different texture. In the development of head lettuce soil texture also plays an important role. This type of lettuce is largely grown on the Atlantic coast soils, which predominate in the coarser grades of sand. When head lettuce is grown in finer-texture soils it does not head up well, and little

or no attempt is made to grow this crop in soils of this nature. Lettuce seed sown in a soil of fine texture will not germinate nearly as well as in loose soil, and lettuce seedlings will reach a certain stage of development, remain stationary for weeks and eventually die. The reason why a fine-texture soil prevents seedlings from developing is lack of air. This may be illustrated by the more vigorous growth which lettuce seedlings make in such a soil near the edge of a flower pot than in the middle, and by various soil aeration experiments.

The compactness of a soil, as might be expected, exerts an influence upon germination and growth. The following table shows the effect of loose and tamped loam and subsoil upon the germination of seeds. In one case a good loam, containing about 8 per cent. of organic matter, was employed, one box being tamped very firmly with a heavy weight after the seeds were sown, and the other left very loose. In the other case two boxes of soil of fine texture (subsoil) were employed. This soil was very deficient in organic matter. These two boxes were treated in a similar way to those containing loam; that is, one was left very loose and the other tamped firmly after the seeds were sown. In all the boxes very little soil was placed over the seed.

Result of Seed Germination in Loose and Tamped Soils.

	Loam.		Subsoil.	
	Loose.	Tamped.	Loose.	Tamped.
Lettuce, 200 seeds,	75	–	51	–
Rattlebox, 200 seeds,	80	22	33	7[1]
White clover, 400 seeds,	146	7	45	–

[1] The seedlings came up in cracks in the soil.

No lettuce seed germinated in the tamped loam or subsoil, while white clover made its appearance in the tamped loam. Rattlebox, which with us is quite at home in fine-texture soil lacking organic matter, did better than the lettuce or white clover. None of the seed possessed a high percentage of germination, and some allowance must be made for this. All of the seed germinated better in the loose loam than in

the loose subsoil, and the rattlebox and white clover showed greater capacity for adaptability to tamped soil than the lettuce.

Lettuce is remarkably susceptible to lack of soil aeration, as is shown by the many experiments we have made with this plant. The following table shows the effect of soil texture upon the germination and growth of lettuce. The boxes employed in this experiment were eight inches square, and each was nearly filled with carefully sifted coal ashes, containing particles corresponding to the sizes given in the table. Each box was weighed and watered daily, and the amount of water applied was such that the degree of saturation was equal to one-half the water-retaining capacity.

Influence of Soil Texture on the Germination of Lettuce Seeds and Growth of Seedlings.

	Size of Particles (Millimeters).	Per Cent. of Germination.	Average Weight of Seedlings (Milligrams).
Box 1,	2–1	54.2	40–60
Box 2,	1–.5	38.0	80–84
Box 3,	.5–.25	24.8	59.99
Box 4,	.25–.1	33.0	41.45
Box 5,	.1–.0001	14.2	19.25

The preceding table includes the results of three experiments, in which 3,000 seeds were employed. The highest percentage of germination is given by the seeds sown in ashes containing particles having a size of 2–1 millimeters; while the largest average weight of the seedlings is shown by those which were grown in ashes containing particles having a diameter of 1–.5 millimeters. In the case of some experiments in similar boxes with sand the highest percentage of germination took place in the particles ranging from .5 to .25 millimeters; and the largest average weight of seedlings was given by the particles ranging in size from 1 to .5 millimeters, or the same as in the experiment with ashes. It should be pointed out that important differences exist between coal ashes and sand in respect to absorption of

moisture. This was quite noticeable in the experiments, inasmuch as the ashes act like a sponge and water is retained to quite an extent by them; while in the sand no such absorption takes place, as is readily shown by the top layers of the coarse sand becoming dry, — so much so at times that seed germination was seriously interrupted. For this reason it was impossible to maintain the same relative degree of moisture in the various strata in the sand boxes as in the ashes. Since ashes were more porous and spongy, the difference in the amount of moisture in the various strata was less marked, and there was no difficulty in maintaining enough moisture for germination in the coarse particles of coal ashes.

The influence of variation in the soil moisture cannot be eliminated in comparative experiments with soils of different texture, since the capillarity of the different grades of soils is by no means the same; neither is the amount of water which the seeds and seedlings received under these conditions identical.

Some parallel experiments were undertaken in shallow plates, containing about three-fourths inches of coal ashes, having the same range in the size of particles as in the previous experiment, with somewhat similar results. In the plate experiments the difference in the amount of moisture due to the difference in the capillarity was considerably modified, since the substratum was so shallow that the seedlings, after they had become mature to a certain degree, could obtain practically the same amount of water from each type of particles, providing evaporation was checked, thus preventing stimulation which would arise from the difference in the water supply, although the water in the plates containing the coarse particles would be more largely confined to the lower strata. Soil texture and water supply are intimately associated, and this has led some to believe that water constitutes the ruling element in the soil in crop production. Respiration is also an important function in plants, for which process oxygen is necessary. When plants are deprived of oxygen they cease to grow, and seeds will not germinate.

It is important that roots be supplied with air for respiration, as is shown by aeration experiments; and in the experi-

ments with lettuce the difference in the percentage of germination and growth of seedlings in ashes was determined by differences in the air supply furnished by the various grades of particles employed.

Texture of Massachusetts Soils.

For some years this department has made mechanical analyses of soils in connection with the study of problems relating to greenhouse crops, and for various persons who desire to know the constituents of some particular soil. A list including some of the analyses is presented with this report, the soils being grouped in a general way under different headings.

In the list of soils which follows, acknowledgment should be made to those who have taken part in this work, most of whom have been from time to time students and assistants in our laboratory. Some of these soils were analyzed by Mr. Asa S. Kinney, now director of the Botanical Gardens at Mount Holyoke College; others by Messrs. A. A. Harmon, A. C. Monahan, A. L. Dacy, E. H. Scott, L. K. Liang; and particularly Mr. N. F. Monahan, assistant in the laboratory, who has made by far the greatest number of these analyses.

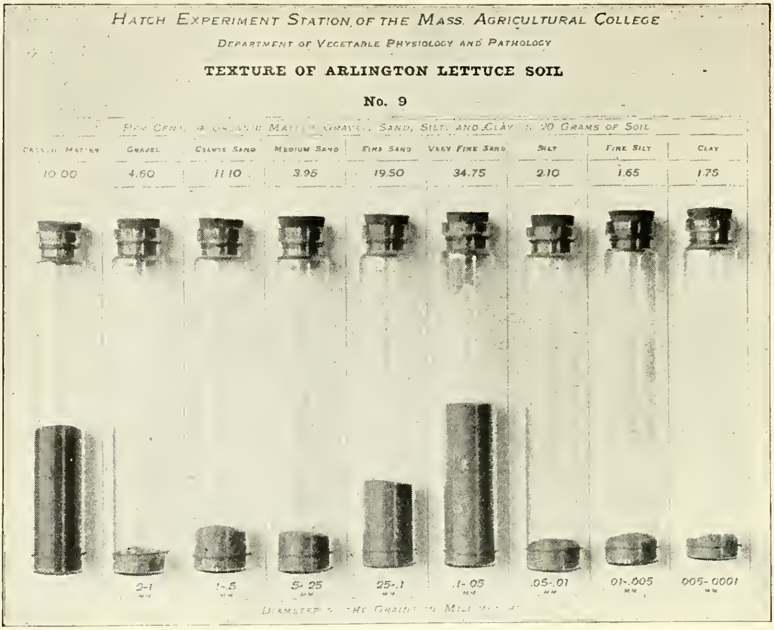
The methods employed are those recommended by Dr. Milton Whitney. In some of the earlier samples the finer-grade material was separated by the gravity method, while all the later analyses have been made by the centrifugal method of separation. In all cases 20 grams of soil were used in each analysis.

The soils best adapted to general market gardening are those which contain considerable proportions of coarse material, which render them loose and friable. Such soils predominate near the coast, and excellent types may be found in many of our river valleys. The soils about Boston, especially those in Arlington, Belmont, Newton, Bedford and Concord, are exceptionally well adapted to market-gardening purposes, and some of the best crops in the United States are raised in these towns. Market gardening has been carried on in the above-named localities for many years, and remarkable skill has been developed in handling certain crops. This statement

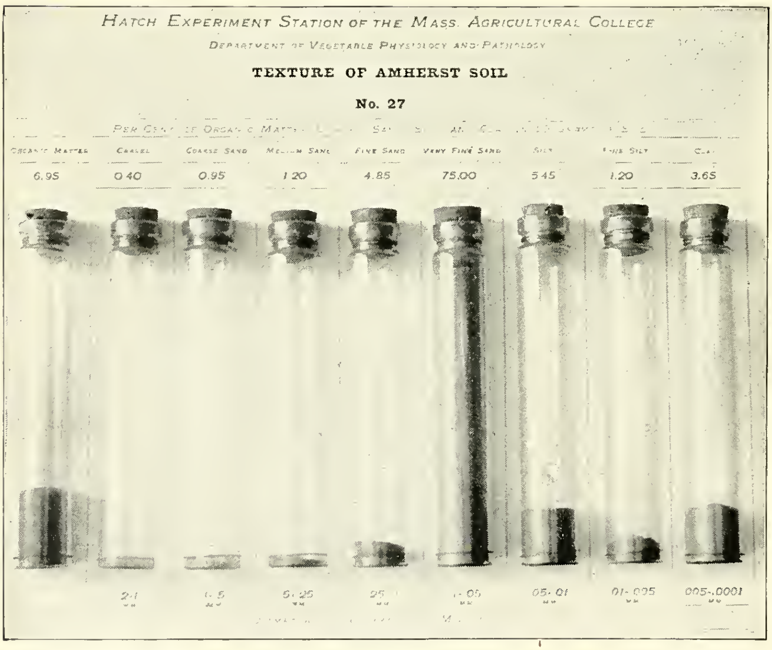
holds true not only in general truck farming, which is followed to a large extent in these regions, but is especially applicable to the cultivation of head lettuce under glass, in which unique skill has been developed.

It is not unusual for market gardeners to put 40 cords of horse manure per acre on the land used for market-gardening purposes, and to a soil devoted to greenhouse lettuce even larger quantities of manure are applied. In general, the best market-gardening soils are those which contain a large amount of coarse material, which is well illustrated by the Belmont, Newton, Concord and Bedford soils. (*Cf.* Table I.)

In a similar class may be included Worcester soil No. 10, New Bedford, Swansea and Touisset. The Worcester soil No. 10 is from a river valley, and is well adapted to the growth of head lettuce. The Providence soil is quite similar to those of Cape Cod, and is somewhat coarser than the Arlington and Belmont types. When these coarser soils are well supplied with organic matter they are suitable for lettuce. The Worcester soils Nos. 13 and 20, together with the Amherst, Huntington and Pittsfield soils, are not desirable ones for head lettuce, since they are too compact. These soils, however, have been used for lettuce, and for this reason are included in this list.



An ideal market-garden soil.



Not well adapted to market gardening.

TABLE I. — *The Mechanical Analyses of Some Market-garden Soils.*

[Diameter of the grains in millimeters (1 millimeter equals about 1/25 of an inch); gravel, 2-1; coarse sand, 1-.5; medium sand, .5-.25; fine sand, .25-.1; very fine sand, .1-.05; silt, .05-.01; fine silt, .01-.005; clay, .005-.0001.]

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
6	Pittsfield, . . .	50.00	11.50	5.35	5.00	4.80	14.00	37.00	7.05	1.20	6.95
9	Belmont, . . .	51.30	10.00	4.60	11.10	3.95	19.50	34.75	2.10	1.65	1.75
14	Subsoil of No. 9, .	29.30	1.80	2.85	8.25	14.30	32.20	32.05	2.30	1.30	2.35
10	Worcester, . . .	46.20	9.01	7.17	15.40	10.10	15.30	29.54	9.85	2.87	2.07
13	Worcester subsoil, .	41.00	9.60	1.40	2.00	3.95	20.70	43.45	7.20	3.05	3.60
15	Newton, . . .	67.90	15.18	5.75	8.12	7.07	12.06	34.01	2.10	0.20	3.82
16	Spencer, . . .	50.00	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
17	Providence, R. I., .	39.60	6.65	9.20	17.85	16.85	20.90	22.50	2.75	0.40	2.25
18	Pittsfield, . . .	61.00	11.00	5.65	6.90	5.25	13.75	35.30	5.95	0.55	3.85
19	New Bedford, . .	40.00	7.60	4.10	5.45	6.45	12.00	39.45	6.95	5.50	5.55
20	Worcester, . .	45.10	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
21	Worcester subsoil, .	36.50	2.80	1.00	1.20	1.10	8.30	66.45	7.35	2.10	5.35
22	Amherst, . . .	40.50	6.00	2.60	5.90	7.90	15.40	40.75	9.25	2.60	4.65
44	Huntington, . .	43.20	8.00	0.36	0.90	1.32	10.09	29.40	27.38	6.35	7.93
47	Concord, . . .	46.59	7.80	5.45	11.01	13.95	25.03	17.87	12.38	0.99	2.75
52	South Sudbury, .	59.93	9.40	2.59	5.79	7.93	25.19	26.38	12.74	2.45	0.98
57	Bedford, . . .	67.21	12.64	3.80	5.30	5.40	15.02	22.91	19.63	7.34	3.37
65	Waltham subsoil, .	54.01	4.32	0.83	1.58	1.94	10.82	44.81	21.15	4.49	7.25
77	Belmont, . . .	42.66	13.20	3.18	5.85	12.13	37.34	14.12	3.60	0.59	1.73
89	Swansea, . . .	61.80	10.44	4.80	5.07	13.19	21.72	22.88	14.60	1.36	3.49
95	Touisset, . . .	51.30	11.66	2.37	3.59	13.63	19.44	32.39	13.22	0.79	1.64
97	Belmont, . . .	50.00	10.57	6.49	5.84	10.49	11.65	30.25	9.33	4.78	4.01

The greenhouse cucumber soils given in Table II. are from widely separated localities, and, with the exception of the organic matter which they contain, are no better adapted to the growth of cucumbers than soils which may be selected from other places. One special feature, however, in connection with these soils is the large amount of organic matter which they contain, which greatly modifies their texture. Most greenhouse soils are rich in organic matter, which is furnished by the extensive use of horse manure and de-

composed sod. Cucumbers are not so susceptible to soil texture as lettuce, since almost any soil fairly well provided with organic matter is suitable for their growth; while in the cultivation of head lettuce it is necessary to have, in addition to a good supply of organic matter, a certain percentage of the coarser particles of soil.

The best method of preparing soil for cucumbers consists in mixing one-third horse manure, one-third loam and one-third sod. These constituents form a suitable basis for a good cucumber soil, and by the extensive use of horse manure each year it can be kept in good condition.

TABLE II. — *The Mechanical Analyses of Some Cucumber Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
34	East Brookfield, .	50.66	6.00	7.80	21.18	18.57	17.01	21.96	2.89	2.18	2.25
74	Athol, ...	57.30	22.46	8.71	12.80	7.33	12.39	8.85	13.21	2.59	1.39
75	Lincoln, . . .	57.00	11.00	2.36	6.18	7.87	24.66	29.89	13.33	0.83	3.14
76	Fitchburg, . . .	42.70	26.02	2.71	7.91	6.45	13.05	12.64	18.33	3.36	1.33
94	Beverly, . . .	66.40	12.13	6.21	6.94	12.26	10.97	29.48	15.32	1.55	1.39

Asparagus is usually grown on a coarse, sandy soil, generally deficient in organic matter, partly for the reason that such soils will not grow anything else satisfactorily. It by no means follows, however, that asparagus requires this type of soil, since, as a matter of fact, the best beds in the State are located on soil of finer texture than most of those shown in Table III.

Such soils as Nos. 33 and 73 possess finer textures than others, and they are excellent asparagus soils, besides having the advantage of growing crops which are not subject to the summer stage of the rust; whereas plants grown in coarse soils are often severely attacked by the rust, regardless of their location. The most important feature connected with asparagus soil in respect to texture is its ability to supply water during periods of excessive drought, which enables the plants to resist outbreaks of rust. In some cases asparagus beds will yield $1,000 per acre.

TABLE III. — *The Mechanical Analyses of Some Asparagus Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
1	Eastham, . . .	38.99	2.00	9.38	27.91	25.09	21.43	8.70	1.40	0.77	1.44
7	Orleans, . . .	35.28	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
8	Concord, . . .	49.81	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.79	1.08
32	Subsoil of No. 8, .	33.66	1.77	9.69	12.75	11.80	19.23	24.30	14.70	2.24	0.78
30	Attleborough, . .	48.76	7.54	9.26	11.15	7.87	11.53	29.57	10.95	2.52	1.42
31	Montague, . . .	33.46	2.74	0.18	2.75	14.77	23.30	44.39	6.16	1.16	3.27
33	Montague, . . .	48.71	1.86	0.27	4.39	19.86	43.88	25.75	2.64	0.36	0.14
45	Concord, . . .	42.95	12.60	6.90	12.03	10.88	21.43	15.44	6.00	5.50	2.98
46	Concord, . . .	32.82	3.20	0.73	2.69	5.69	31.73	37.84	4.48	1.30	4.30
48	Longmeadow, . .	27.34	2.80	3.52	14.88	15.90	25.48	21.60	5.46	1.21	4.31
53	South Sudbury, .	33.64	3.38	0.65	3.22	9.18	40.27	30.29	2.47	1.75	1.99
55	South Berlin, . .	29.54	2.30	5.33	17.70	10.13	11.98	14.08	23.43	4.49	3.58
73	South Deerfield, .	34.00	1.68	1.33	6.76	22.68	31.12	18.41	6.89	1.53	3.49
2	Eastham, . . .	37.13	2.60	17.93	28.80	18.85	5.80	19.15	2.85	1.34	0.66

The soil of the Connecticut valley may be described as loam, predominating in fine sand and silt, and is quite different from soils found in other parts of the State. (*Cf.* Table IV.) It is remarkably free from stones, and well adapted to the growth of onions, tobacco, pickle cucumbers and various other crops. In some parts of the valley, where the soil is mixed with coarser material, good greenhouse lettuce is grown. The most important crops, however, are onions and tobacco, and the former crop is considered better than that raised in any other part of the State. Dr. Milton Whitney, chief of the Soil Bureau, who has investigated and mapped the Connecticut valley soils, implies that they are not so well suited to the growth of the best quality of tobacco as some of the types of Connecticut soil, but they yield heavily, which enables the tobacco grower to derive considerable income from this crop.

There is an opinion prevailing among farmers that some of the Connecticut valley soils are better adapted to the growth of onions than tobacco. The greater proportion of both crops

is grown on what Dr. Whitney terms "Connecticut meadow" and "Podunk fine, sandy loam;" and we cannot say whether onions require, for their best development, soil differing very materially in texture from that required for tobacco.

TABLE IV. — *The Mechanical Analyses of Some Tobacco and Onion Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
11	Hatfield, . . .	33.33	3.78	0.05	0.13	0.30	3.38	60.35	26.29	0.71	4.34
12	Sunderland, . .	37.80	6.76	0.03	0.25	0.50	3.92	21.87	47.86	14.70	2.71
54	North Hatfield, . .	63.38	5.73	0.03	0.20	0.25	6.30	37.87	32.85	5.13	5.01
58	Sunderland, . .	32.38	4.72	0.13	3.32	0.43	5.83	52.18	23.40	2.12	1.54
59	Easthampton, . .	31.18	4.40	0.07	0.42	0.75	10.84	62.43	7.51	0.41	1.03
61	Hadley, . . .	38.78	5.32	0.05	0.28	0.33	1.08	51.46	24.01	7.75	7.00
62	Subsoil of No. 61, .	36.23	4.65	0.08	0.41	1.76	11.32	56.56	17.56	4.25	1.03
63	Double subsoil of No. 61.	34.77	2.40	0.56	0.33	4.98	2.33	50.68	18.80	11.33	6.36
70	Sunderland, . .	65.50	8.22	0.10	9.45	1.44	4.35	40.01	29.67	0.46	5.65
78	Whately, . . .	50.00	10.34	1.65	3.42	12.66	36.29	11.24	14.69	0.59	0.79
90	Whately, . . .	49.30	8.17	1.20	2.29	12.37	35.29	21.39	15.44	0.68	1.49

There is no greenhouse specialty which requires so much skill as the growing of roses, and the magnificent specimens which may be found in the markets at almost any season of the year surpass all other greenhouse products in beauty and perfection. There is no plant which requires so heavily manured a soil as the rose. The customary formula for mixing such a soil is one-third finely pulverized sod, one-third loam and one-third cow manure. In addition to this, some form of commercial fertilizer is occasionally applied. Watering the plants with a strong decoction of cow manure is frequently practised.

It is highly impracticable to use a soil of this nature for two consecutive seasons, since, owing to its high state of fertilization and the subsequent chemical changes which take place in the soil, a toxic effect is produced upon the plants. No class of greenhouse specialists is more particular about

the texture of the soil employed than rose growers, especially when growing the American Beauty. American Beauties are more susceptible to differences in soil texture than other varieties of roses, and a perfectly satisfactory soil for their growth has not as yet been found in this State. They require soil of a different texture from Brides and Bridesmaids.

The rose soils in the list (*Cf.* Table V.) were obtained from various sources, some of which are noted for their production of excellent roses; while others are prospective rose soils, — that is, soils sent in by rose growers who wished to ascertain whether they were well adapted to the growth of roses. It will be noticed that most of these analyzed rather high in very fine sand and silt, while two of the samples contained nearly 10 per cent. of clay.

TABLE V. — *The Mechanical Analyses of Some Rose Soils.*

Station Number.	Locality.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
3	Natick, ...	43.50	9.20	4.50	6.55	6.30	13.22	32.17	5.67	1.18	9.17
29	Madison, N. J., . .	52.10	9.96	3.87	7.10	8.10	13.77	26.77	8.85	1.20	9.40
35	Clifton, N. J., . .	64.30	7.90	3.60	13.50	18.77	17.83	23.30	8.59	1.66	3.53
43	Tarrytown, N. Y., .	54.06	8.10	.19	3.00	4.58	13.69	22.88	22.25	11.25	5.94
67	Amherst, . . .	56.50	8.96	3.51	3.25	3.87	9.75	45.42	14.49	.99	3.86
79	Westborough, . .	49.20	6.06	3.21	3.13	6.92	8.80	35.81	21.14	.99	4.31
81	Subsoil of No. 79, .	34.00	3.86	5.05	3.41	7.60	13.83	38.90	19.64	.73	3.77
82	Westborough, . .	60.24	6.99	3.07	3.23	7.77	9.25	47.81	16.28	.40	1.22
80	Subsoil of No. 82, .	36.00	3.88	5.52	4.61	9.29	13.36	26.12	26.25	.87	3.87
84	Westborough, . .	42.00	8.96	4.59	4.29	9.18	13.35	22.04	26.70	1.97	2.87
85	Natick, ...	57.90	9.10	4.76	4.00	9.61	15.08	25.57	25.55	.90	1.48
86	Subsoil of No. 85, .	33.50	3.57	7.41	6.20	14.70	18.80	25.83	9.97	11.06	1.17
88	Natick, ...	48.00	6.02	4.73	4.19	9.80	15.74	30.00	21.75	1.41	2.59
87	Subsoil of No. 88, .	60.25	4.71	4.35	3.58	8.36	11.25	33.77	26.47	1.04	4.01

Throughout Massachusetts there are many hills of an oval shape, whose long axes run in a northerly and southerly direction. These "clay hills" are designated "drumlins" by geologists, and in some parts of the State, notably on the

ridge passing through Worcester county, they are abundant and symmetrical in outline, forming the most picturesque part of the landscape.

While these are commonly termed "clay hills," their surface soil cannot be classed as such, although it is a heavy, rather cold soil, especially adapted to the growth of some of the coarser grasses, like timothy. They make excellent pastures for cattle, and many of the best dairies in the State are located in regions where these hills prevail. (*Cf.* Table VI.)

Drumlins were formerly much valued by the Indians for agricultural purposes, since historical research reveals that many of them were cleared of forest growth at the time of the first English settlement in New England. They are well supplied with water, as is shown by the fact that crops grown on them seldom suffer from drought. They are largely cleared of forest growth to-day, because they are now, as in early times, highly valued for agricultural purposes. The original growth of trees consisted of chestnut, and where forests exist on these hills at the present time they consist mainly of this species.

TABLE VI. — *The Mechanical Analyses of Some Drumlin Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
4	Spencer, ...	40.70	8.50	5.32	6.80	8.88	21.96	32.51	8.07	2.02	3.05
49	Southbridge, . .	44.05	7.44	6.55	9.20	4.23	23.53	22.36	15.90	3.92	5.12
50	Subsoil of No. 49, .	33.30	3.20	5.98	8.18	6.07	15.78	16.84	19.60	13.05	6.23
51	Subsoil of No. 49, .	26.60	2.74	5.43	10.21	11.78	16.73	19.83	18.80	9.05	.39
83	East Brookfield, .	35.25	6.97	8.67	6.53	11.93	16.55	21.33	18.98	1.59	3.90

Of the remaining soils, a variety of types are represented. (*Cf.* Table VII.) A large number of these were taken from the experiment station grounds, and they predominate in very fine sand, which causes the soil to become quite compact when wet. They resemble the general type of Connecticut

valley soils, and are not well adapted to the growth of greenhouse crops. The Oxford soil is from a river valley, and is suitable for truck farming. Soil No. 96 is from the Berkshire hills, and No. 56 from a Worcester county town, with an elevation of approximately 1,000 feet.

The analysis of earthworm castings is similar to that of the soil in which the earthworms live, with the exception of a small amount of organic matter.

TABLE VII. — *The Mechanical Analyses of Some Miscellaneous Soils.*

Station Number.	LOCATION.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
5	Amherst experiment station.	68.45	7.32	.95	1.05	1.72	7.29	66.19	6.96	1.33	4.13
25	Amherst experiment station.	35.40	7.00	.25	.65	.90	4.45	74.15	5.01	.65	4.05
23	Amherst experiment station.	42.50	8.60	2.80	1.80	3.05	10.70	50.95	6.70	2.35	6.50
24	Amherst subsoil, .	31.33	3.60	1.75	4.45	6.95	23.85	35.95	11.10	5.20	5.25
26	Amherst experiment station.	32.33	6.72	.35	.81	1.73	9.15	64.69	10.70	1.13	2.35
27	Amherst experiment station.	33.66	6.95	.40	.95	1.20	4.85	75.00	5.45	1.20	3.65
28	Amherst experiment station.	50.00	9.36	3.10	6.08	4.86	3.81	57.87	2.61	1.46	.73
36	Oxford, . . .	66.70	7.30	7.95	8.45	5.28	6.54	44.34	12.13	2.26	1.11
37	Amherst experiment station.	36.33	2.24	.34	4.03	5.03	6.64	74.42	1.98	.73	2.40
38	Earthworm castings.	67.76	9.60	2.10	7.51	7.45	13.40	39.26	12.13	3.21	1.79
39	Marshfield, salt marsh.	81.66	17.90	.00	.27	1.95	10.37	32.01	13.40	9.87	10.07
40	Marshfield, salt marsh.	81.33	17.50	.37	1.48	1.30	8.20	22.77	34.38	4.98	5.40
41	Wayland, fresh marsh.	142.50	77.39	.00	.30	.25	.50	2.10	.20	.45	13.05
42	Brick clay, . .	46.00	2.96	.00	.00	.00	.02	.16	15.18	15.83	64.15
56	Charlton, . .	65.13	11.10	3.07	5.62	6.41	9.28	22.51	17.97	3.84	3.57
60	Drift land, . .	25.16	.66	.13	1.08	7.85	61.06	25.82	.53	1.01	.51
64	Amherst subsoil, .	45.00	1.28	.82	2.27	2.26	13.35	29.53	14.40	14.42	12.55
66	Amherst experiment station.	59.01	9.80	.69	3.86	3.63	6.51	36.53	14.27	12.25	9.43
68	Amherst experiment station.	54.75	6.58	.99	1.48	1.53	12.51	28.02	14.51	14.11	10.41
69	Amherst experiment station.	65.25	18.21	1.45	4.40	3.85	12.93	38.13	1.50	.51	12.26
71	Amherst experiment station.	76.60	7.54	1.24	3.62	3.48	11.64	49.01	10.85	1.55	1.71
72	Amherst subsoil, .	86.10	.11	2.25	3.10	2.61	4.13	13.02	12.25	5.30	49.35
96	Franklin, . .	44.60	8.26	4.83	3.83	7.07	6.52	32.91	25.16	1.09	2.12
101	Belmont, . . .	39.33	8.42	8.90	5.59	18.64	26.19	18.48	3.40	2.60	1.63
104	Monson, . . .	37.50	8.98	3.54	2.99	9.16	17.45	19.36	27.94	2.75	3.36

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD.

Outline of Work.

Four main lines of work have occupied the attention of the entomological division of the station during 1906: correspondence, experimental investigations, special research and the preparation of results for publication.

The correspondence during the year has been unusually large in amount, and has extended over a much longer period than is usual. The largest amount of this work generally comes between the first of May and the end of August, but this year it began in March and continued until into December. Of course during the remaining months numerous letters are received and answered, but the bulk of the correspondence has now not only increased beyond that of previous years, but has extended over a longer period.

No unusual devastation has been reported during the past year, but all of our injurious insects seem to have been abundant, and have caused their share of loss in one line or another.

Experimental investigations have been begun or continued from previous years along a number of lines. The prevalence of the white fly in greenhouses has caused much loss, and information as to the methods of controlling this insect has been in great demand. For this purpose fumigation with hydrocyanic acid gas appears to be the most successful if made at the proper intervals of time and in the proper way; but this gas is also injurious to plants, and how much these can stand under varying conditions of light, temperature, humidity, length of exposure to the fumes, etc., has not been de-

termined for different kinds of plants at different ages. This has accordingly been made a subject of particular investigation during the past year.

Tomatoes were the first crop tested, the usual greenhouse varieties being selected; and the plants were fumigated at all stages of growth and under varying conditions, to determine in each case the maximum amount of gas which could be used without injury. These experiments have now been completed, and demonstrate that it is possible to fumigate tomatoes with a sufficient strength of cyanide to destroy the white fly without injuring the plants, provided certain conditions are carefully observed. The information thus obtained has already been supplied to a number of persons who have had trouble with the white fly in their greenhouses, and has been used successfully, and a bulletin on the subject is now being prepared. At the present time a similar series of experiments with cucumbers, another important forcing-house crop, and one also seriously injured by the white fly, is in progress.

The prevalence of root maggots of various kinds during the past few years has called attention to the need of a more thorough study of the methods for controlling these insects; and a series of tests of these methods was begun last spring, the intention being to try different treatments recommended, and obtain evidence as to their comparative value. For various reasons, however, it was impossible to complete these experiments during the season, and it is planned to repeat them on a larger scale next year.

The last two summers have been unusually favorable for the rapid increase and distribution of the San José scale. This pest has been in Massachusetts for about fifteen years, and in the localities where it was first introduced has spread in all directions for some distance. New centers of infestation, however, have been constantly established from the planting of infested stock of one kind or another; and while five years ago most of these centers were already in existence, the number of scales at each was so small that their presence was generally unsuspected. It would seem that during the first two or three years in any locality this scale spreads but

little, as the plant it is on furnishes all the food supply needed; but as these plants become thoroughly covered with the scales, the young find it more difficult to obtain their food without wandering farther from where they were born, and apparently more of them under these conditions get upon the feet of birds or larger insects which alight where they are, and are thus carried away to infest other parts. The result of this is a general infestation of the region, following four or five years after the local infestation; and it is probable that this condition of affairs was reached generally in Massachusetts about 1904. Following this were two summers extremely favorable for a rapid increase of these pests; and we now find them in great abundance in many places where their presence has not before been suspected, and quite generally scattered through the State.

Whether this explanation, which naturally is more or less theoretical, be correct or not, the fact remains that the correspondence of this station shows that the San José scale was probably present in one or more somewhat restricted areas in nearly every town in Massachusetts east of the Connecticut River in 1904; while at the present time it would probably be easy to find it in a dozen places in each of these towns, and as frequently on large, old trees as on recently set ones.

Though this insect attacks a large number of kinds of plants, those of most importance to man are the fruit trees and certain ornamental trees and shrubs; and these, accordingly, are the ones which will receive attention in the way of treatment. A number of extensive studies in the treatment of the San José scale were begun at this station in 1902, at which time the conclusion was reached that the most successful treatment was obtained by the use of the lime and sulfur mixture. Farther experiments along this line have been made as opportunities offered, and the results reached still confirm that conclusion. Last spring over eight hundred trees belonging to the college were sprayed with a number of different preparations, and a study of the results was made during the entire summer and fall. The inconvenience in making the lime and sulfur mixture, resulting from the neces-

sity of boiling the materials for from forty minutes to an hour, has led to an attempt to avoid this by adding materials which would continue the boiling begun by the slaking of the lime for a sufficient length of time to obtain the desired chemical combinations. Several of these "self-boiling mixtures" were tested last spring, but none of them gave as good results as the lime and sulfur mixture prepared in the usual way. Perhaps the best of these "self-boiling mixtures" was that obtained by a mixture of 20 pounds of lime, 14 pounds of sulfur and 10 pounds of sal-soda in 40 gallons of water. Similar combinations, substituting sodic sulfid or caustic soda for the sal-soda, were more expensive and gave less satisfactory results.

The Derror tree fluid was also tested in the course of these experiments, but so far as could be observed failed to be of the slightest benefit in any case.

The K. L. mixture, which has been recommended by the Delaware Experiment Station, also gave unsatisfactory results, besides being quite expensive.

The Rex lime-sulfur solution was applied in four different ways, in accordance with the suggestions of the manufacturers, but none of the four gave satisfactory results, although a small proportion of the scales was killed.

Scalecide, applied at the rate of 1 gallon to 22 gallons of water, proved to be something of an insecticide, killing many of the scales; but applied with the same apparatus, by the same men and on the same day, as the ordinary lime and sulfur mixture, it failed to give anything like as good results. From reports which have been received, however, from other places, it is probable that this material, used at greater strength, in two applications and under great pressure in the pump, may prove quite effective.

Observations for determining dates of appearance of the young of the oyster-shell and scurfy scale have been continued, and the same observations have been made for the white pine scale, as upon the time when the young appear entirely depends the time at which successful treatment can be given.

The raising of cranberries in Massachusetts is a very important industry, in which a large amount of capital is

invested, and the annual value of the product is over a million dollars. The cranberry plant has a number of serious insect enemies, and fifteen years ago the subject of cranberry insects was given much attention at this station, and the results obtained at that time were published. Farther study on the subject has been greatly needed, but it was impossible to make these anywhere except on the bogs themselves, and until the present year arrangements for this could not be made. Last spring, however, it was found possible to again take up the study of cranberry insects under the local conditions found on the bogs, and an investigator spent five months in continuous study of these insects on the bogs around Wareham. Many of the problems connected with the control of cranberry pests have been solved, as a result of this investigation; but many new problems have appeared in the course of the work, which make it desirable to continue the study farther, and it is the present intention to have an investigator spend six months at least during the coming year in continuing the observations begun last summer. That the results thus far have been so satisfactory is due in a great measure to the hearty co-operation in the work given by the Cape Cod Cranberry Growers' Association, and of many individuals connected therewith.

During the latter part of last winter some very remarkable cocoons found in Dorchester were sent to this division by the Gypsy Moth Commission, and were found to be the cocoons of some foreign insect. Subsequently the moths which emerged from them were identified as being native in China and Japan, and concerning which very little appears to be known. The possibility that this insect may become a pest in this country is so great that it has seemed wise to thoroughly investigate its present distribution, abundance, probable means by which it reached this country, and all that is already known of it, and this work has taken much of the time during the last two months of this year. Apparently this insect, which may for convenience be designated the Oriental moth, has been in this country for six or seven years, and it is at least possible that it was introduced on nursery stock imported from Japan. It has now spread over a considerable territory

in Dorchester, where it is quite abundant. The caterpillar feeds upon the leaves of a large number of our more common fruit and shade trees. While it is yet too soon to determine whether it will become a serious pest, the experience this State has had with the gypsy and brown-tail moths has been of such a nature that it is the part of wisdom to investigate all such importations as this, and be at least prepared for the worst. The insect has already shown that it can live in our climate, that it can become quite abundant, and that it has few if any enemies. At the present time in Asia it is present over twenty degrees of latitude, corresponding to the distance from Florida to Labrador in this country. A bulletin giving all the information thus far obtainable about this insect has already been issued, and further studies of it will be made the coming year.

The other subjects outlined in this report have taken so much time that little has been done along the line of special research, only one paper having been published, though several topics are now in hand, and the work on them occupies the few odd minutes not taken by other duties.

Insects of the Year.

The insects which have caused much loss in Massachusetts during 1906, as indicated by the correspondence of the station and also by personal observation, have been of many kinds. The condition of this State as regards the San José scale has already been described, and the correspondence about this pest has been very great in amount. In connection with this, the oyster-shell scale, the scurfy scale, the rose scale, the white pine scale and several kinds of Lecaniums have required a considerable amount of attention. Many letters with reference to the gypsy moth and brown-tail moth have also been received, and have either been answered from here, or the writers referred to the Gypsy Moth Commission, which now has charge of the work of controlling these insects. The elm-leaf beetle is gradually becoming more abundant, and has again reached the point where its numbers are sufficient to greatly injure the appearance of our elms. During the spring months an unusual abundance of the spiny elm cater-

pillars was noticed, and in some places they seriously injured the appearance of the trees. Plant lice of various kinds were also much in evidence; and many specimens of tussock moths, particularly the old tussock moth, were sent to the station for identification. Many inquiries about cutworms were received, but the correspondence on this topic was less than during the two years preceding; while inquiries about wire worms and the best treatment for them were more abundant than usual. In greenhouses the white fly is a serious pest, causing the loss of thousands of dollars, and much correspondence; while thrips, which was so much in evidence a few years ago, was inquired about but twice. The asparagus root miner, an insect not hitherto reported in this State, has made its appearance in several places in sufficient abundance to cause considerable injury. But little is known of the life history of this insect, and further investigations upon it are planned for the coming season.

As a whole, the important insects this year have been of so many different kinds that it has been impossible to give to most of them the uninterrupted attention which is needed, even for our most abundant forms, in order to test the best methods of control. There is no insect known about which more information would not be of assistance in leading to the discovery of better remedies than we now have; and it is most desirable that the insects causing the most loss in any year shall be carefully studied at the time, in the hope of finding better methods of control. Such conditions as have prevailed during the past season, therefore, where work of this kind has been almost impossible on account of so many calls for information in different directions, produce a year which must be considered as more or less unsatisfactory in the way of results; and this was certainly the case in 1906.

VETERINARY DEPARTMENT.

This newly organized department of the station has been in operation since July 1 of the present year. Previous to this the veterinary work in the station has been attended to by the veterinary department of the college.

Each year for the past fifteen years there has been an increasing demand from the stock owners of the State for information concerning veterinary subjects. This demand has come to the station in the form of requests for lectures and publications, and correspondence relative to animal diseases, or to the nature of material sent for examination. The specimens that have been received have come from various parts of the State, and have consisted of diseased tissues of the larger animals, or in some instances the cadavers of the smaller farm animals; and in some cases the products of the animals, such as milk, eggs, etc. This material has been subjected to a close examination, oftentimes a microscopical study and bacteriological examination, requiring a large amount of time and labor to complete it. Living animals sent for study and examination have been kept under observation in the hospital, where experiments have been conducted to obtain definite information regarding the nature of the particular affection, as regards cause, effects, contagiousness and other closely related matters. Upon the completion of the work written reports have been sent to those from whom the specimens have come, advising them of the nature, cause, treatment or prevention of the particular affection.

On several occasions visits have been made to farms in different parts of the State, to investigate outbreaks of disease of a character peculiar either on account of the circumstances under which the disease made its appearance, the form it

assumed, or the peculiarity of the symptoms accompanying its development. Experiments conducted at the station, and on the farm in conjunction with the owners of the animals, have in several instances been fruitful of most favorable results, either in arresting the progress of the disease or in preventing its recurrence.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

Outline of Work.

The work of the department of horticulture continues on the lines laid down several years ago, and set forth in previous reports of this station. The principal experiments undertaken deal with problems in the propagation of fruit trees, in pruning, and in the systematic study of varieties of fruits. These all require a considerable number of years to secure definite results, and no report on these experiments would be justified at this early date.

Incidental to other work, a few experiments of minor importance have been underway, such as cross-grafting herbaceous plants, test of varieties of strawberries, details of certain methods in market-garden practice, some study of thermo-physiological constants, the practical application of digesting fluids in the germination of seeds, the growing of mushrooms, etc. A short report on the experiment last mentioned is appended herewith.

Notes on Mushroom Culture.

Opportunity has offered during the last two years to make several practical experiments in mushroom culture. The principal matter at issue, aside from a demonstration of methods, was the comparative value of the new pure-culture spawn. Several commercial varieties of these so-called tissue or pure-culture spawn were tested and compared, and comparison was made with the common commercial English spawn and with the French spawn. The results are summarized below.

Mushrooms were grown under the ordinary conditions. No special houses were provided. For the most part, beds were made up under greenhouse benches in a house used for bedding out stock. In one instance beds were made in an unused cellar. This work was under the direct charge of Mr. Francis Canning, head gardener.

As has been said, the usual methods were followed. For instance, in the fall of 1904 a bed was made up, November 19. This was spawned November 30 with common English spawn and with a few varieties of pure-culture spawn. The first picking was made on January 6. The entire crop from a bed of 75 square feet was something over 50 pounds. This amount was sold for an average of 35 cents a pound, bringing a total of a trifle over $17.50. This gives an average return of approximately 24 cents per square foot. Part of this crop was sold locally in quart strawberry boxes, which will hold one pound of mushrooms when heaping full. A considerable amount of the crop was shipped to Boston, selling from 40 to 50 cents a pound, yielding a net average of 33 cents a pound.

In the fall of 1905 the experiment was renewed, greater care being taken to equalize all conditions, and to give a fair test on the comparative value of varieties used. Five pure-culture varieties were included in this planting, as follows: Alaska, Columbia, Bohemia, Galloway and Agaricus arvensis (this last is the variety now called Eureka). In separate sections of the same bed the common English and the French spawns were included. The following table shows the results of this experiment. The time of first picking is indicated, and of the last picking, thus showing the length of season. The total weight is given, and dates are added to indicate at what time of the season the beds were most productive. In the last column is shown the number of pounds produced by each bed during its most productive week.

Comparison of Varieties, 1905–06.

Variety.	Spawned.	First Picking.	Last Picking.	Total Weight.	Square Feet of Bed Surface.	Weight per Square Foot of Surface (Pounds).	Week most Productive.	Amount for Week (Pounds).
Alaska,	Oct. 26,	Dec. 11,	March 10,	7 lbs. 4 oz.,	9	.777	Dec. 11–18,	3.375
Galloway,	Oct. 26,	Dec. 16,	Jan. 25,	3 lbs. 8 oz.,	9	.388	Dec. 23–30,	2.000
Columbia,	Oct. 26,	Dec. 16,	March 10,	6 lbs. 4 oz.,	9	.666	Dec. 29–Jan. 9,	2.500
Bohemia,	Oct. 26,	Dec. 15,	March 10,	5 lbs. 14 oz.,	9	.555	Dec. 27–Jan. 2,	2.125
Arvensis,	Oct. 26,	Dec. 15,	March 10,	13 lbs. 14 oz.,	9	1.555	Dec. 23–30,	5.500
English,	Nov. 3,	Jan. 8,	March 10,	4 lbs. 12 oz.,	18	.222	Feb. 10–17,	1.500
French,	Nov. 3,	Feb. 24,	March 10,	8 oz.,	18	.027	March 10,	.375

It will be seen that the pure-culture varieties gave much larger yields than either the English or the French spawn. While this difference is very great in this experiment, indicating probably an inferior grade of English and French spawn, all our experiments have shown a similar advantage for the pure-culture varieties. Indeed, it seems to be one of the chief advantages of the new method of growing mushroom spawn from pure culture that it nearly always gives fresher and more vigorous spawn. The product is nearly always more uniform, and of higher quality; but, while this advantage is important, it is not so great as the one already mentioned.

A comparison of the different varieties shows that Eureka (Agaricus arvensis) leads all the others in productivity, Alaska coming second. This has been the result in all the experiments in which these varieties have been tested. Eureka is darker colored than any of the other varieties, and sometimes not quite so well shaped; nevertheless, it is solid and heavy, and of fairly good quality when cooked. Galloway is a white, small, delicate variety, the best of all for eating, but not sufficiently productive to pay the grower.

The following conclusions may fairly be drawn from the experiments: —

1. Pure-culture spawn is as a rule very much better than either English or French spawn.

2. There are important points of difference between the commercial pure-culture varieties; these differences consist in color, flavor, form, and above all else in productivity.

3. The most productive variety thus far tested is Eureka. Several other varieties are promising.

As a general result of our experience, it may be said that mushrooms can often be grown profitably as a catch-crop in cellars or under greenhouse benches where conditions are favorable. The most important favorable condition to be considered is a cheap and reliable supply of fresh horse manure. It is quite plain, however, from our experience, that the stories of sudden wealth accumulating from mushroom-growing are mostly fictitious.

Public Document No. 31

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The State Board of Publication.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1907.

To His Excellency CURTIS GUILD, Jr.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the forty-fifth annual report of the trustees of the Massachusetts Agricultural College, for the fiscal year ended Nov. 30, 1907.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

CONTENTS.

College Calendar for 1908-1909.

1908.

January 2, Thursday, 8 A.M., winter recess ends.
February 1, Saturday, semester examinations begin.
February 10, Monday, 8 A.M., second semester begins.
February 22, Washington's Birthday, — holiday.
March 25, Wednesday, 6 P.M., spring recess begins.
April 2, Thursday, 8 A.M., spring recess ends.
April 19, Patriots' Day, — holiday.
May 15, Friday, Burnham prize essay contest.
May 30, Memorial Day, — holiday.
June 1, Monday, senior examinations begin.
June 8, Monday, non-senior examinations begin.
June 17, Wednesday, commencement exercises.
June 18, 19, Thursday to Friday, entrance examinations.
Long vacation.
September 14, 15, Monday and Tuesday, entrance examinations.
September 14–16, Monday to Wednesday: (*a*) condition examinations; (*b*) enrolment in classes.
September 16, Wednesday, 1.30 P.M., assembly, — first semester begins.
November 25–30, Wednesday, 1 P.M., to Monday, 1 P.M., Thanksgiving recess.
December 18, Friday, 6 P.M., winter recess begins.

1909.

January 4, Monday, 1 P.M., winter recess ends.
February 1, Monday, semester examinations begin.
February 8, Monday, 1 P.M., second semester begins.
February 22, Monday, Washington's Birthday, — holiday.
March 26, Friday, 6 P.M., spring recess begins.
April 5, Monday, 1 P.M., spring recess ends.
April 19, Monday, Patriots' Day, — holiday.
May 30, Memorial Day, — holiday.
June 7, Monday, senior examinations begin.
June 15, Tuesday, non-senior examinations begin.
June 19–23, Saturday to Wednesday, commencement exercises.
June 24, 25, Thursday to Friday, entrance examinations.

The Corporation.

	TERM EXPIRES
Arthur G. Pollard of Lowell,	1909
Charles A. Gleason of New Braintree,	1909
Frank Gerrett of Greenfield,	1910
Samuel C. Damon of Lancaster,	1910
W. W. Rawson of Arlington,	1911
Charles H. Preston of Danvers,	1911
Carroll D. Wright of Worcester,	1912
M. Fayette Dickinson of Boston,	1912
William H. Bowker of Boston,	1913
George H. Ellis of Boston,	1913
J. Howe Demond of Northampton,	1914
Elmer D. Howe of Marlborough,	1914
Nathaniel I. Bowditch of Framingham,	1915
William Wheeler of Concord,	1915

Members ex Officio and Officers.

His Excellency Governor Curtis Guild, Jr.,
President of the Corporation.

Kenyon L. Butterfield, *President of the College.*
George H. Martin, *Secretary of the Board of Education.*
J. Lewis Ellsworth, *Secretary of Board of Agriculture.*

Charles A. Gleason of New Braintree,
Vice-President of the Corporation.
J. Lewis Ellsworth of Worcester, *Secretary.*
Fred C. Kenney of Amherst, *Treasurer.*
Charles A. Gleason of New Braintree, *Auditor.*

Standing Committees of the Trustees.[1]

Committee on Finance.

George H. Ellis, J. Howe Demond,
Arthur G. Pollard, Charles H. Preston,
Charles A. Gleason, *Chairman.*

[1] The president of the college is *ex officio* member and secretary of standing committees. The director of the experiment station is a member of the committee on experiment department, without vote.

Committee on Course of Study and Faculty.

William H. Bowker,
M. Fayette Dickinson,
George H. Martin,
Elmer D. Howe,
Carroll D. Wright,
William Wheeler, *Chairman.*

Committee on Farm and Horticulture.

Farm Division.

George H. Ellis,
Frank Gerrett,
Charles A. Gleason,
N. I. Bowditch, *Chairman, and Chm. Joint Committee.*

Horticultural Division.

Arthur G. Pollard,
Elmer D. Howe,
J. Lewis Ellsworth, *Chairman.*

Committee on Experiment Department.

J. Lewis Ellsworth,
William H. Bowker,
W. W. Rawson,
Samuel C. Damon,
Charles H. Preston, *Chairman.*

Committee on Buildings and Arrangement of Grounds.

William Wheeler,
Frank Gerrett,
Wm. H. Bowker,
N. I. Bowditch,
M. F. Dickinson, *Chairman.*

Examining Committee of Overseers.

John Bursley (*Chairman*),	of West Barnstable.
W. C. Jewett,	of Worcester.
E. L. Boardman,	of Sheffield.
Isaac Damon,	of Wayland.
Frank Gerrett,	of Greenfield.

Officers of the Institution.

THE FACULTY OF THE COLLEGE.

Kenyon L. Butterfield, A.M., President of the College and Professor of Rural Sociology, 25 Sunset Avenue.

George F. Mills, M.A., Dean of the College, Head of the Division of the Humanities and Professor of Languages and Literature, 46 Amity Street.

Frank A. Waugh, M.S., Head of the Division of Horticulture and Professor of Landscape Gardening, Massachusetts Agricultural College.

Charles Wellington, Ph.D., Professor of General and Agricultural Chemistry, 34 Amity Street.

Charles H. Fernald, Ph.D., Professor of Zoölogy, 3 Hallock Street.

William P. Brooks, Ph.D., Professor of Agriculture and Director of the Experiment Station, Massachusetts Agricultural College.

James B. Paige, D.V.S., Professor of Veterinary Science, 42 Lincoln Avenue.

George E. Stone, Ph.D., Professor of Botany, Mt. Pleasant.

John E. Ostrander, M.A., C.E., Professor of Mathematics and Civil Engineering, 33 North Prospect Street.

Henry T. Fernald, Ph.D., Professor of Entomology, 44 Amity Street.

George C. Martin, C.E., Captain, Eighteenth U. S. Infantry, Professor of Military Science and Tactics, Amherst House.

William R. Hart, A.M., Professor of Agricultural Education, 46 North Pleasant Street.

Fred C. Sears, M.Sc., Professor of Pomology, Mt. Pleasant.

Philip B. Hasbrouck, B.S., Associate Professor of Mathematics, Adjunct Professor of Physics, Registrar, 130 Pleasant Street.

Fred C. Kenney, Treasurer, Mt. Pleasant.

James A. Foord, M.Sc., Associate Professor of Agronomy, 35 North Prospect Street.

Samuel F. Howard, B. Sc., Assistant Professor of Chemistry, 10 Allen Street.

Clarence E. Gordon, A.M., Assistant Professor of Zoölogy, North Amherst.

Robert W. Neal, A.M., Assistant Professor of English and Instructor in German, 56 North Pleasant Street.

George N. Holcomb, A.B., S.T.B., Assistant Professor of Political Science, 10 Lincoln Avenue.

A. Vincent Osmun, M.Sc., Assistant Professor of Botany, North Amherst.

Edward A. White, B.Sc., Assistant Professor of Floriculture, 55 Pleasant Street.

Robert W. Lyman, LL.B., Lecturer on Farm Law, Northampton.
Frank W. Rane, M.S., Lecturer on Forestry, State House, Boston.
Sidney B. Haskell, B.Sc., Instructor in Agriculture (on leave of absence).
Augustus Armagnac, Ph.D., Instructor in French, 35 North Prospect Street.
Harold F. Tompson, B.Sc., Instructor in Market Gardening, Wilder Hall.
Frank M. Gracey, Instructor in Landscape Gardening, 58 Pleasant Street.
William M. Thornton, Jr., A.B., A.M., Instructor in Chemistry, 14 Amity Street.
Arthur D. Holmes, B.S., Instructor in Chemistry, 96 Pleasant Street.
Ernest C. Fowler, B.S., Instructor in Chemistry, 96 Pleasant Street.
Ray L. Gribben, B.S.A., Instructor in Animal Husbandry, 66 Pleasant Street.
Earle G. Bartlett, B.Sc., Instructor in Botany, 69 South Pleasant Street.

OTHER COLLEGE OFFICERS.

Miss E. Frances Hall, Librarian, North Amherst.
Elwin H. Forristall, M.Sc., Farm Superintendent, Massachusetts Agricultural College.
Miss Grace M. Knowles, B.S., Secretary to the President, Draper Hall, Massachusetts Agricultural College.
Newton Wallace, Electrician, 6 Phillips Street.
E. Charles Rowe, Steward of the Dining Hall, Massachusetts Agricultural College.
Miss Cornelia Ball, Stenographer, Division of Horticulture, North Amherst.
Miss Vesta C. Haney, Bookkeeper, Draper Hall, Massachusetts Agricultural College.
Miss Mary Caldwell, Stenographer, Draper Hall, Massachusetts Agricultural College.

ADDITIONAL INSTRUCTORS IN SHORT COURSES.

A. *Summer School of Agriculture, 1907.*

E. H. Scott, Registrar and Instructor in Plant Culture.
Philip Emerson, Instructor in Methods.
Clarence Moores Weed, Instructor in Insect Life.
E. H. Forbush, Instructor in Bird Life.
H. D. Hemenway, Instructor in School Gardening and Practical Gardening.

B. *Winter Course in Dairy Farming, 1908.*

William G. Langwill, Butter Expert.
H. A. Parsons, Instructor in Babcock Testing.
Nathan J. Hunting, B.S., Instructor in Use of Separators.
Charles W. Hooker, B.A., Instructor in Entomology.

EXPERIMENT STATION STAFF.

WILLIAM P. BROOKS, Ph.D., Director and Agriculturist, Massachusetts Agricultural College.

CHARLES A. GOESSMANN, Ph.D., LL.D., Expert Consulting Chemist, 40 Amity Street.

JOSEPH B. LINDSEY, Ph.D., Chemist, 47 Lincoln Avenue.

GEORGE E. STONE, Ph.D., Botanist and Vegetable Pathologist, Mt. Pleasant.

CHARLES H. FERNALD, Ph.D., Entomologist, 3 Hallock Street.

JAMES B. PAIGE, D.V.S., Veterinarian, 42 Lincoln Avenue.

FRANK A. WAUGH, M.S., Horticulturist, Massachusetts Agricultural College.

JOHN E. OSTRANDER, C.E., Meteorologist, 33 North Prospect Street.

HENRY T. FERNALD, Ph.D., Associate Entomologist, 44 Amity Street.

EDWARD B. HOLLAND, M.S., Associate Chemist, 28 North Prospect Street.

HENRY D. HASKINS, B.Sc., Chemist (Fertilizer Control), 89 Pleasant Street.

PHILIP H. SMITH, B.Sc., Chemist (Food and Dairy Control), 102 Main Street.

ERWIN S. FULTON, B.Sc., Assistant Agriculturist, 12 Cottage Street.

EDWIN F. GASKILL, B.Sc., Second Assistant Agriculturist, R. J. Goldberg's, North Pleasant Street.

CARL S. POMEROY, B.Sc., Ph.B., Assistant Horticulturist, 19 Phillips Street.

ROBERT D. MACLAURIN, Ph.D., First Assistant Chemist, Research Division, 6 Kellogg Avenue.

EDWARD T. LADD, B.Sc., First Assistant Chemist, Fertilizer Division, 75 North Pleasant Street.

LEWELL S. WALKER, B.Sc., First Assistant Chemist, Feed and Dairy Division, 19 Phillips Street.

WALTER E. DICKINSON, B.Sc., Second Assistant Chemist, Fertilizer Division, Pleasant Street, North Amherst.

GEORGE H. CHAPMAN, B.Sc., Assistant Botanist, 66 Pleasant Street.

HENRY J. FRANKLIN, B.Sc., Assistant Entomologist, Cranberry Investigations, Wareham.

E. A. WHITE, B.Sc., Florist, 55 Pleasant Street.

FRED C. KENNEY, Treasurer, Mt. Pleasant.

E. FRANCES HALL, Librarian, Leverett Street, North Amherst.

FLORENCE L. DACY, Secretary, Draper Hall, Massachusetts Agricultural College.

WILLIAM K. HEPBURN, Inspector, Feed and Dairy Division, Sunderland.

ROY F. GASKILL, Assistant in Animal Nutrition, Massachusetts Agricultural College.

THOMAS A. BARRY, Observer, South College, Massachusetts Agricultural College.

JESSIE V. CROCKER, Stenographer, Department of Botany and Vegetable Pathology, Sunderland.

HARRIET COBB, Stenographer, Department of Plant and Animal Chemistry, 33 Cottage Street.

Report of the President of the College.

Gentlemen of the Corporation of the Massachusetts Agricultural College.

I submit herewith my second annual report as president.

Attendance.

The total attendance for the college year ended June 30, 1907, was as follows: —

Graduate students,	8	
Special students,	1	
Senior class,	24	
Junior class,	57	
Sophomore class,	61	
Freshman class,	77	
		228
Short courses: —		
Winter course,	38	
Bee course,	10	
		48
		276
Names counted twice,		1
Total enrollment,		275

This table shows an increase of 14 in the total registration of students of college grade over the previous college year. The registration of college grade students Nov. 30, 1907, is 244, as compared with 225 at the same time a year ago. For the present college year we will also be able to add a registration of 212 for the summer school of agriculture, so that the total number of different names to be listed in our forthcoming catalogue will approximate 500.

Appropriations.

The following is a list of the appropriations asked by the trustees of the last Legislature, and the amounts granted: —

	Asked.	Granted.
Increase of instruction (annual),	$7,000	$4,000
For equipping barn, stable and milk room,	3,000	3,000
For purchase of live stock for the barn,	7,000	4,000
For equipping and furnishing Clark Hall,	25,000	24,400
Boiler for heating and lighting plant,	2,000	2,000
Equipment, maintenance and minor improvements,	14,000	14,000
Greenhouse and work rooms,	22,000	–
	$80,000	$51,400

New Buildings.

The furnishing and equipping of Clark Hall was unduly delayed, and it was not until nearly the first of November that classes were being held regularly in the building. The total appropriation for building, furnishing, and equipping Clark Hall was $70,000. This appropriation will not be exceeded, and we have a building of great beauty, with splendid equipment and most modern conveniences, and one in every way worthy the college. A description of the building, with floor plans, was given in the last report of this Board.

The new barn was accepted by the committee on new buildings and arrangement of grounds at Amherst, July 16. The total cost was $41,000. This structure gives us unusual facilities for work in modern dairy practice, and it ought to prove one of the most useful buildings for educational as well as for practical purposes. A description, with plans and elevation, will be presented for publication in the annual report.

Commencement.

The commencement of 1907 represented the completion of forty years of actual college work at this institution. Special efforts were made to emphasize the anniversary feature of the occasion. A day was set apart for the alumni, and they were urged to attend freely. The alumni dinner proved to be one of the largest gatherings of graduates of the institution ever assembled. The exhibition of loyalty and enthusiasm for the college equalled the measure of attendance. The commencement address was given by one of the

best-known graduates of the college, President Charles S. Howe of the Case School of Applied Science, Cleveland, O., of the class of '78. President Howe's subject was, "Does a Technical Course educate?" The number of students receiving diplomas was: B.S., 23; M.S., 2; Ph.D., 1.

Summer School.

The summer school of agriculture grew out of a legislative enactment providing for a normal department at this institution, for the purpose of giving instruction to teachers desiring to teach the elements of agriculture in the public schools. The school opened July 8 and continued four weeks. Four main courses were offered, — plant structure and life, plant culture, animal life, teaching methods. In addition to lectures there were out-of-door practicums daily, Saturday excursions and evening lectures. The total enrollment was 212. Practically all of these were teachers, and a large proportion were residents of Massachusetts. We are satisfied that the summer school resulted in a great increase of interest among teachers in the whole problem of agricultural education, and that incidentally the college gained many friends.

Conference on Rural Progress.

The fortieth anniversary of the opening of the college to students occurred Oct. 2, 1907. Acting under vote of your Board, arrangements were made for a conference on rural progress, to begin on this date and to continue four days. The conference was designed to celebrate the anniversary to some degree by papers of historical interest, but chiefly by a program dealing with the various phases of rural life in Massachusetts in such a way as to indicate the unity of the rural problem in the Commonwealth, the natural leadership of the agricultural college in helping to solve that problem and in bringing together representatives of the various agencies which are at work for rural betterment. The program of the conference is printed elsewhere in this report.

The attendance was not so large as had been hoped; not so many as could be wished remained for most of the sessions; however, the attendance was good, and increased each day. The audience was made up of people interested; the spirit and purpose of the conference were fully appreciated; the press was exception-

ally generous in its reports and comments. On the whole, we have reason to congratulate ourselves upon the results of this endeavor.

I would recommend that the historical papers presented at the first session of this conference, by Mr. M. F. Dickinson, William H. Bowker and Prof. William P. Brooks, be printed in the annual report.

While it is probably inadvisable to repeat precisely this sort of meeting in the near future, I recommend that provision be made for other meetings of similar purpose, to be held under the auspices of the college, either at the college or at strategic points throughout the State.

Changes in Faculty.

The most notable faculty change of the year was the resignation of Dr. Charles A. Goessmann as professor of chemistry. Dr. Goessmann had been connected with the college for a period of nearly forty years, and had given to the work of research and instruction in chemistry powers of a very high grade. A large proportion of the graduates of the college have been under his instruction, and his work in connection with the experiment station is of world-wide reputation. His resignation was due to advancing years. Both Dr. Goessmann and the college were honored in the fact that on dropping college work he became the recipient of a pension from the Carnegie foundation. He retains his connection with the experiment station as expert consulting chemist.

The headship of the department of general and agricultural chemistry in the college was given to Dr. Charles Wellington, an alumnus of the class of 1873, who has been associate professor of chemistry since 1885, and who has had charge of the chemical laboratory of the college since that time.

Prof. George F. Mills accepted the appointment as dean of the college, and began his duties as dean at the opening of the present college year. Dean Mills has rare qualities for this work, and brings to it not only long experience in teaching, but a thorough sympathy with the students and their best interests. Professor Mills also became head of the division of the humanities, including at present the departments of language and literature, political science and the library.

The position of treasurer was filled by the election of Mr. Fred C. Kenney, who for the past twelve years was cashier of the Michigan Agricultural College. He assumed his duties July 1. Mr. Kenney has had ample training in accounting, and his experience has given him unusual insight into the problems of business administration in an institution of this character.

The trustees, acting under the law creating a normal department at this college, organized a department of agricultural education, and elected to that position Prof. William R. Hart of Peru, Neb. Professor Hart was educated in Iowa, and has his master's degree from the University of Nebraska. He has taught successfully in the various grades of schools, and for the past four or five years has been connected with the State Normal School of Nebraska. He has given special attention to work in the biological sciences, is in thorough sympathy with agriculture, was recommended as a teacher of rare power, and he has chosen to specialize in agricultural education because he believes in its essential value from the educational point of view and in the great future that lies before it.

At the beginning of the college year the division of horticulture was organized, with Prof. F. A. Waugh in charge. Professor Waugh retains the professorship of landscape gardening.

Prof. F. C. Sears of Nova Scotia, a graduate of the Kansas Agricultural College, was elected professor of pomology in the division of horticulture. Professor Sears brings to this new work ample experience both in teaching and in field work, and comes at a time when the problem of orcharding in Massachusetts may well receive earnest attention.

Mr. Francis Canning resigned his position as instructor in floriculture and greenhouse management, after a successful service of nearly four years. The trustees voted to create the position of assistant professor of floriculture, and elected to that position Prof. E. A. White of the Connecticut Agricultural College, a graduate of this college in the class of 1895. Mr. G. A. Bishop of Wayland acceptably filled the position of instructor pending Professor White's arrival.

The place made vacant by the resignation of Mr. M. A. Blake a year ago was filled by the appointment of Mr. H. F. Tompson as instructor in market gardening and superintendent of the field work. Mr. Tompson is a graduate of the class of 1905.

I wish at this point to emphasize the importance of the organization which the trustees have developed in the division of horticulture. Not only has the department been strengthened by the election of new men, but the differentiation of the work will surely lead to a higher grade of teaching and a much greater development of the various coördinated lines.

Prof. F. S. Cooley, assistant professor of agriculture, resigned last August to accept the position of farmers' institute superintendent in Montana. Professor Cooley was a graduate of the college in the class of 1888, had served as agriculturist in the station and as farm superintendent, and since 1893 had been assistant professor of agriculture, giving the work in animal husbandry and dairying. Professor Cooley was a genial teacher, a close student of pure-bred stock and a popular lecturer at farmers' institutes. His place was temporarily filled by the appointment for the present college year of Mr. R. L. Gribben, a graduate of the Iowa State College, class of 1906.

Mr. S. B. Haskell, instructor in agriculture, was granted leave of absence for the present college year for the purpose of study abroad. Prof. James A. Foord was appointed for one year, to carry on Mr. Haskell's work, with the title of associate professor of agronomy. Professor Foord is a graduate of the New Hampshire College of Agriculture and Mechanic Arts, has done graduate work at Cornell, and had served acceptably at the Delaware State College and in the College of Agriculture of the Ohio State University.

After the college year had opened, Mr. L. R. Herrick, instructor in French and Spanish, received a flattering offer from the University of Wisconsin, and, as it seemed best that the college should not stand in the way of this promotion, he was released from his duties here. Mr. Herrick had been with the college four years, was an exceedingly competent teacher, and gave the institution his best energy and ability. We were fortunate in immediately securing the services of Dr. A. Armagnac, a resident of Amherst and a teacher of long experience.

Mr. A. Vincent Osmun was made assistant professor of botany at the opening of the college year.

Mr. C. P. Halligan resigned last spring as instructor in drawing, to accept a position in horticulture in the Michigan Agricultural College. At the opening of the college year the position of

instructor in landscape gardening was created, and Mr. Frank M. Gracey, a graduate of the Boston Normal Art School, was appointed to the position.

Mr. C. G. Barnum resigned as instructor in chemistry at the end of the last college year. His place was filled by the appointment of Mr. William M. Thornton of Charlottesville, Va. Mr. Thornton has received his bachelor's and master's degrees from the University of Virginia.

Two new assistantships in the department of general and agricultural chemistry were created at the opening of the college year, and there were elected to these positions Mr. Arthur D. Holmes, a graduate of Dartmouth College, of the class of 1906, and Mr. E. C. Fowler, from the Michigan Agricultural College, class of 1907.

The assistant's work in botany, performed last year jointly by Mr. Franklin and Mr. Back, is being carried on this year through the appointment of Mr. Earle G. Bartlett, class of 1907, as instructor in botany. Mr. John N. Summers, also of the class of 1907, is assisting in some of the instruction work in the department of entomology.

At the beginning of the experiment station year last summer there was effected a somewhat important administrative reorganization, which will be described in full by the director of the station in his report.

Changes in Entrance Requirements.

The catalogue of 1906–07 embodied changes in the requirements for entrance in the following-named groups of subjects: —

I. Languages.

II. History and civil government.

III. Mathematics and science.

These changes were: —

1. In language, a requirement of one year's study of either French or German for entrance was added, students being required to pursue for two years in college that language not offered for entrance.

2. In history, United States history was added as a requirement; and instead of general history alone, applicants were permitted to offer either general history, ancient history, medieval and modern history or English history.

3. In mathematics and science, physical geography was dropped from the list of required subjects, and instead students were given the option of offering physiology, chemistry or solid geometry. The chemistry and solid geometry were new subjects among the requirements; physiology was already required. Applicants who do not offer physiology, however, must take that subject in college.

The catalogue for 1907–08 contains no changes in entrance requirements; but a provision is announced under which qualified students may receive advanced standing in English. This enables them to begin their college study of the subject at a less elementary point, thus effecting a material saving of time for them.

Administrative and Business Organization.

During the year the trustees voted to establish a division of the humanities and a division of horticulture, — the former to include the departments of language and literature, of political science, the library, and such other departments of like character as may be added in the future. The division of horticulture embraces the departments of pomology, of floriculture and of landscape gardening, with market gardening practically, though not officially, recognized as a department. It is believed that this form of organization will assist materially in emphasizing the important phases of college work, as well as in the general financial and administrative affairs of the college.

The new treasurer began his duties July 1, and in accordance with your vote gives all his time to the work of the treasurership.

The committee on finance have authorized a plan of requisitions, accounting and apportionment, which takes effect at the beginning of the ensuing fiscal year, Dec. 1, 1907. Full details of this plan will be found elsewhere in this report. It attempts to center the business of the institution in the treasurer's office, requiring that requisitions of supplies be countersigned by the treasurer. All bills are to be paid by him; all receipts are to come to his office, that his books may contain a complete record of every financial transaction of the whole institution. In connection with this scheme the apportionment of college funds to various departments has been revised, and it is hoped that, while heads of departments may enjoy large freedom in the business administration of their departments, estimates may be more carefully made than heretofore, and funds apportioned more exactly in accordance with the

need, in order that the trustees and the Legislature may be made more fully cognizant of the expenditures and needs of the entire institution.

Sales of Products.

A special committee appointed by your trustees early in the year reported an arrangement by which heads of departments were instructed not to retail in the local market products grown on the college grounds, when such sale competed with similar products grown by local producers. It is too early to make sure of the precise financial results of this policy. The effect on the farm department has not been material. The chief losses are in the division of horticulture. I shall endeavor to present a fuller discussion of the result of this policy at a future time.

Reaching the People.

I think it is generally agreed that it is absolutely essential to the life of a college like ours that it shall reach out among the working farmers of the State and even into the farm homes, and, indeed, shall touch all the people who are interested in rural matters. The college has always done this to a greater or less degree. There is, however, a movement now stirring all over the country which looks toward organizing this work on a larger and more comprehensive scale than ever before. It is a work that, while helping the institution directly, is not done primarily for selfish purposes, but for the purpose of rendering aid to the people who need it. There are various ways of doing this outside work. I still think that the plan suggested in my report of a year ago, of organizing what might be called an extension department, on a somewhat comprehensive scale, is the best way. If there is a better plan, I shall be very glad indeed to advocate it. I do feel, however, that we shall not be true to our constituency or live up to our possibilities unless work of this kind is attempted in an important and far-reaching way.

Finances.

During the last fiscal year the expenditures of the college for current purposes exceeded the income by a sum ranging from $1,500 to $2,000, it being impossible to state the exact figure, because there is no way of knowing at this moment the precise

amount of outstanding bills. This deficit would not have occurred if it had not been for two or three unavoidable facts, namely: the poor fruit season, which decreased the sales of fruit in comparison with previous years; the restriction as to sale of flowers and greenhouse plants in the vicinity, which reduced the income by several hundred dollars more; and the requirement of an eight-hour day. The division of horticulture alone, although employing no more hours of labor than the year previous, expended $900 more for labor bills. This statement regarding the deficit for the last fiscal year has not taken into consideration the dining hall, which is not yet on a paying basis, and which has a deficit of $3,000.

The treasurer's books also show, however, that the college is carrying a deficit of approximately $13,000. This is a deficit which is not revealed by the cash account, simply because of the manner and time in which the United States and the State funds are paid into our treasury. A thorough accounting, however, would bring out the fact stated. There is also a deficit of approximately $3,700 in the building of the barn. The Burnham emergency fund has not yet been replaced. It seems to me that, while this financial situation is not a pleasant one to face, it ought to be met frankly and promptly. When it is considered that during the past seven or eight years the college has come into possession of four or five large new buildings which have to be maintained, that the number of departments has increased as well as the number of the instruction force, and that the attendance of four-year college students has in this same period nearly doubled, while the current annual income has increased only about one-fourth, we find a sufficient explanation of this deficit in the current accounts. I believe this matter ought to be explained to the Legislature, and that we need not hesitate to ask for a special appropriation which shall enable us to balance our books.

It is unfortunate that the college should fail to erect a building within the appropriation granted by the Legislature; but it ought to be remembered in the case of the barn that a definite plan and estimate were presented to the Legislature, and that, when the appropriation asked for was materially reduced, one wing of the barn was taken out of the plans. To reduce the cost further would have meant practically destroying the integrity of the plans,

and an entirely different scheme of operations than was proposed. Furthermore, I believe that the barn is well built, and that we need have no hesitation in asking the Legislature to make up this small deficiency in construction.

Needs of the College.

I wish to urge upon the trustees the desirability of asking the Legislature for an increase in our current maintenance income. Under the new plan of apportionment adopted by the finance committee, we shall be enabled to make reasonably close estimates for our budget against our known and probable resources, and in this way determine the current needs of the institution. Provided our apportionment is carefully made, it should represent very closely the actual need of the institution; and it ought to be evident to the Legislature that we cannot be expected to maintain our plant, equipment and teaching facilities, and at the same time keep out of debt, unless the current annual maintenance measures up to the existing need.

If the institution is to enlarge its usefulness and develop its function as a first-class agricultural college, it will be necessary every year to establish additional departments and take on new instructors. Under existing conditions this cannot be done unless the annual income from the State for instruction purposes is increased. It would be a great delight to the administration if the Legislature would see fit to pass a law by which our annual current appropriation for instruction should be increased each year by a sum of not less than $5,000. I feel very sure that we could use this added amount to good advantage. However, our needs for the present year, in my judgment, call for an increase in our annual current income of not less than $13,000. It is desirable to establish immediately a division of agriculture, and to employ a man who will act as head of this division and give all his time to the work of instruction in the agricultural branches. As an assistant we should also call a man who can take charge of the dairy work. The time has arrived when this college ought to have on its faculty an instructor in hygiene and physical culture. Instructors in mathematics and German are imperatively needed for next year. We should also organize our graduate work in some definite form, and a small amount for this purpose should be made available.

The trustees have made provision for a director of short courses, but no provision has been made for the expenses of this officer. The summer school of agriculture has proved its value, and should be adequately supported. The total amout of $5,000 now appropriated for the normal department is needed for definite instruction in the regular college work and in supervisory work; hence the Legislature should, in my opinion, be asked to make an appropriation to cover the expenses of the summer school of agriculture. I therefore recommend that the Legislature be asked to appropriate not less than $8,000, to be placed at the disposal of the director of short courses, for the purpose of developing further the winter school of agriculture, the summer school of agriculture and similar lines of work.

The commandant has in several reports called attention to the need of a target range. An option has been secured on a desirable piece of land for this purpose, and I recommend that the Legislature be asked to appropriate $1,000 to purchase the land and prepare it for the range.

The college does not possess an adequate athletic field. This fact handicaps the work of athletics and physical culture in this institution in a very serious way, limits the range of activities of the students, and imposes rather serious financial obligations upon the men. It might seem that, with 400 acres of land at our disposal, a site for an athletic field on college property could be secured. So far this has not proved possible; indeed, after a thorough investigation by the directors of the Alumni Athletic Association, it seems impracticable. The alternative is that the college should endeavor to secure an appropriation from the Legislature to purchase land adjacent to the college, a part of which may be used as a site for a permanent athletic field. I have reason to think that the alumni would furnish the finances for fitting up this field, if obtained.

There are pressing needs of additions to our equipment and to the heating and lighting plant; of remodelling North College; of improvements in the library, which will give shelf room for some 10,000 more volumes; of repairs and improvements in the experiment station buildings; and of a fruit storage house; aside from miscellaneous repairs and minor improvements.

For three years in succession the Legislature has refused to grant an appropriation for a new greenhouse. We have very carefully

gone over the needs of this rapidly growing department of our work, and it seems to me that we should press this matter very firmly upon the attention of the Legislature. We should ask for a glass house substantially upon the plans heretofore laid down, and connected with it should be a small brick teaching building, which for the present may house the departments of floriculture and of market gardening, so built that in the future its capacity may be doubled as the needs of the departments grow.

I would also like to urge the pressing need of a building for the department of entomology. I am told that for a number of years this matter has been called to the attention of the trustees, but so far it has not seemed advisable to go to the Legislature with the request for an appropriation for this purpose. The matter is, however, brought home to us rather sharply by the fact that, while 36 of the present seniors elected senior entomology, only 20 could be accommodated in the present laboratory. The enlarging economic importance of entomology, the call for men to fight insect pests, the growing interest in horticulture, carrying with it, as it does, a subsidiary interest in entomology, make it highly important that at this college we shall not fail to provide for the men who really want this sort of work. Furthermore, we are housing in a small frame building property valued at $21,000, some of which could not be replaced at any cost, and all of which constitutes a most valuable collection for the scientific and practical study of this important branch of our work. Such a building would cost at least $60,000 to $75,000.

The Large Sums recommended.

I am quite aware that in thus recommending a program of appropriations for this institution, which, if adopted in full, would call for a legislative appropriation approaching $200,000 in amount, there is danger of seeming to present extravagant needs, and of unwisely pressing upon the attention of the Legislature a call for large appropriations. But this is not done without careful thought. The facts are, that if this institution is to claim a thoroughly modern equipment as a representative agricultural college, with buildings and apparatus sufficient to meet the needs of all the departments of the college and to care for our rapidly increasing body of students, we could utilize immediately for buildings and their equipment

alone not less than half a million dollars. Agricultural education is progressing by leaps and bounds. The demand for it is coming on, even in New England, with great rapidity. The Commonwealth of Massachusetts must rally to our support, if her people expect us to keep in the front ranks. The needs that I have mentioned are real, pressing, immediate needs. They are not items that ought to be looked forward to as for the future, but they are things that ought to be in our possession at once.

Permanent Financial Policy.

I think it is a safe proposition that our financial status as an institution should be such that we will have current funds adequate for the following purposes: —

1. To maintain the existing plant in good condition.
2. To increase our working equipment for the various departments as rapidly as the growth in number of students, in number of instructors and in number of courses may reasonably require.
3. To meet minor emergencies and contingencies which come up during the year, and which cannot possibly be anticipated.
4. For increasing salaries and for unexpected faculty changes.

In addition to these adequate current funds, we need also an increase of resources: —

1. For new buildings and additional land for carrying out the essential purposes of the institution.
2. For such of the larger repairs and improvements as cannot be cared for by ordinary current income.
3. For a material increase in the instruction force.

It would of course be desirable if the money for both these current and special needs could be provided through a permanent annual income, sufficiently large and progressive in amount to enable us to avoid going to the Legislature for annual increases or special appropriations. Many of the western State institutions are provided for in this manner through the working of a mill tax. A tenth mill tax in Massachusetts would, for instance, yield our college over $300,000 annually, and give us an annual increase progressively of about $7,000. If the Legislature of the Commonwealth should, however, prefer that we go to them annually with our special needs, I think there is no objection to doing so, if they are willing to give us credit for judgment and honesty of purpose.

It does seem perfectly obvious, however, that our current annual income should be sufficient, and if possible sufficiently progressive in amount, to meet the current annual needs of a growing institution.

Obituary.

During the year two members of the Board of Trustees have died, — Mr. James Draper of Worcester and Mr. M. I. Wheeler of Great Barrington. Mr. Draper had been a member of this Board for twenty years, had served as chairman of important committees, and had given much of his time and energy to the institution. As chairman of the committee on new buildings and arrangement of grounds, he has been active in securing for the college the new buildings which have been erected since 1900, and which are a decided credit to the institution. His attitude toward the college was thoroughly disinterested, and he gave to it as freely of his thought and enthusiasm as he could possibly have given to a private venture. The trustees have recognized his work to a degree by giving the name of "Draper Hall" to the dining hall, and ordering that a proper tablet and a suitable picture shall be placed in the hall as a memorial of Mr. Draper.

Mr. M. I. Wheeler had been a member of the Board for some fourteen years, and was especially interested in the practical work of the management of the farm. Advancing years had prevented him from active participation, though he never lost his interest in the college.

A former member of the Board also died during the year, Mr. O. B. Hadwen of Worcester.

Respectfully submitted,

KENYON L. BUTTERFIELD.

Nov. 30, 1907.

Legislative Budget.

[As adopted by the committee on finance, Jan. 10, 1908.]

The committee on finance, acting under authority conferred by the Board of Trustees of the college, at a meeting held at the college Jan. 10, 1908, voted to request of the Legislature the following appropriations for the year 1908: —

I. Deficiency Appropriations.

1. Deficit in current funds,	$13,000 00	
2. Deficit in cost of barn,	3,690 10	
Total,		$16,690 10

II. Increase in Current Annual Appropriation.

3. Increase in maintenance to cover regular apportionment,	$2,000 00	
4. Increase in instruction appropriation,	13,000 00	
5. Increase in current annual appropriation to cover cost of short courses and correspondence courses,	8,000 00	
Total,		23,000 00

III. Special Apportionment.

6. Target range and equipment,	$1,000 00	
7. Repairing and refitting experiment station buildings,	4,000 00	
8. Addition to electric light plant,	6,000 00	
9. Repairing and refitting North College,	6,000 00	
10. Enlargement and improvement of library facilities,	2,500 00	
11. Department equipment,	8,000 00	
12. Miscellaneous repairs and minor improvements,	7,700 00	
13. Fruit storage house,	2,500 00	
14. Glass houses, attached teaching building and equipment for same,	34,000 00	
Total,		71,700 00
Grand total,		$111,390 10

Report of the Treasurer.

Balance Sheet, Fiscal Year ending Nov. 30, 1907.

		Dr.	Cr.
1906.			
Dec. 1,	Cash on hand at beginning of fiscal year,	$16,521 29	–
1907.	Advertising,	–	$675 91
Nov. 30,	Appropriation,	1,692 41	455 80
	Agricultural,	1,495 02	2,589 30
	Agricultural laboratory,	24 26	137 96
	Band,	–	97 70
	Burnham emergency fund,	75 00	130 00
	Botanical laboratory,	460 93	381 32
	Entomological laboratory,	98 16	68 72
	Expense,	3,032 60	8,731 99
	Farm,	7,195 21	14,309 25
	Furniture,	–	79 50
	Heating and lighting,	3,134 43	13,016 65
	Horticultural,	5,015 80	9,928 45
	Insurance,	1,965 94	13,831 10
	Library,	210 34	1,909 40
	Salary,	–	30,952 83
	Term bill,	3,493 64	1,510 97
	Zoölogical laboratory,	182 00	218 88
	Chemical laboratory,	870 04	447 23
	Veterinary laboratory,	916 66	356 83
	Landscape gardening,	122 50	89 41
	Nelson fund,	3,333 33	–
	Morrill fund,	16,666 67	10,125 10
	Endowment,	14,263 32	–
	Instruction,	14,916 66	–
	Maintenance,	4,583 33	–
	Scholarship,	13,750 00	–
	Student labor,	4,583 33	5,303 96
	Student deposits,	1,079 85	507 49
	Extra instruction,	–	200 00
	Tools,	–	3 60
	Cash on hand,	–	3,623 37
	Totals,	$119,682 72	$119,682 72

Statement of Receipts and Disbursements for Fiscal Year ending Nov. 30, 1907.

	Receipts.	Disbursements.	Apportionment.	Department Balance.
Advertising,	–	$675 91	$750 00	$74 09
Agricultural,	$1,495 02	2,589 30	1,500 00	405 72
Agricultural laboratory,	24 26	137 96	–	—113 70
Band,	–	97 70	–	—97 70
Botanical laboratory,	460 93	381 32	–	79 61
Chemical laboratory,	870 04	447 23	–	422 81
Entomological laboratory,	98 16	68 72	–	29 44
Landscape gardening,	112 50	89 41	–	23 09
Veterinary laboratory,	916 66	356 83	–	559 83
Zoölogical laboratory,	182 00	218 88	–	—36 88
Expense,	3,032 60	8,731 99	3,200 00	—2,499 39
Farm,	7,195 21	14,309 25	2,500 00	—4,614 04
Furniture,	–	79 50	–	—79 50
Horticultural,	5,015 80	9,928 45	2,500 00	—2,412 65
Heating and lighting,	3,134 43	13,016 65	7,700 00	—2,182 22
Library,	210 34	1,909 40	1,609 34 [1]	—89 72
Salaries,	–	41,277 93	38,321 60	—2,956 33
Term bill,	3,493 64	1,510 97	–	1,982 67
Receipts from United States government,	8,333 33	–	–	–
Morrill fund, . $16,666 67				
Nelson fund, . 3,333 33				
$20,000 00 [2]				
Receipts from Commonwealth,	47,513 31	–	–	–
Endowment, . $14,263 32				
Instruction, . 14,916 66				
Maintenance, . 4,583 33				
Scholarship, . 13,750 00				
$47,513 31				
Totals,	$82,088 23	$95,827 40	$58,080 94	—$11,504 87

[1] This apportionment has been increased by $209.34 from the library fund, which was not turned over at this date.

[2] Of this amount, $11,666.67 should be on hand for payment of salaries from Dec. 1, 1907, to July 1, 1908.

Outstanding Accounts.

Bills receivable,	$2,142 40	
Bills payable,		$3,066 09

Institution Deficits.

Current account,	$13,739 17
Burnham emergency fund,	3,000 00
New farm barn,	3,690 10
Dining hall,	3,187 77
	$23,617 04

Inventory — Real Estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,150 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,225 00	
South dormitory,	35,500 00	
North dormitory,	25,400 00	
Chemical laboratory,	8,200 00	
Entomological laboratory,	5,000 00	
Veterinary laboratory and stable,	23,125 00	
Farmhouse,	2,050 00	
Horse barn,	5,020 00	
Farm barn and dairy,	41,000 00	
Graves house and barn,	1,560 00	
Dining hall,	35,450 00	
Mathematical building,	5,600 00	
Wilder Hall,	37,300 00	
Tool house,	2,000 00	
Horticultural barn,	2,525 00	
Clark Hall,	66,091 85	
Durfee plant house and fixtures,	10,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,700 00	
Amounts carried forward,	$354,171 85	$44,350 00

Amounts brought forward,	$354,171 85	$44,350 00
Dwelling houses purchased with farm,	5,100 00	
Power house,	12,000 00	
		371,271 85
Total,		$415,621 85

Equipment (Estimated Value).

Botanical department,	$6,984 48	
Horticultural department,	16,147 12	
Farm,	25,565 13	
Chemical laboratory,	2,803 17	
Entomological laboratory,	1,945 00	
Zoölogical museum,	6,150 00	
Zoölogical laboratory,	3,300 00	
Veterinary laboratory,	6,107 92	
Physics and mathematics,	2,100 00	
Dairy school,	1,394 10	
Agricultural department,	2,528 52	
English department,	74 00	
President's office,	844 34	
Dean's office,	74 00	
Treasurer's office,	300 00	
Text-books,	607 83	
Library,	28,868 00	
Military department,	623 50	
Fire apparatus,	259 60	
Heating and lighting,	41,647 71	
Dining hall,	2,078 96	
		$150,403 38

EXPERIMENT STATION.

Buildings (Estimated Value).

Agricultural laboratory,	$9,000 00	
Chemical laboratory (plant and animal chemistry),	20,000 00	
Entomological laboratory,	1,700 00	
		$30,700 00

Equipment (Estimated Value).

Director's office,	$1,573 21	
Agricultural laboratory,	6,785 20	
Entomological laboratory,	19,040 00	
Botanical laboratory,	3,255 47	
Chemical laboratory,	16,620 69	
		$47,274 57

Cost of Construction of New Barn and Dairy.

	Amount Available.	Cost.
Amount appropriated by Legislature for barn, dairy and piggery,	$25,300 00	–
Amount available from insurance fund,	11,968 45	–
Contract for barn, dairy and two silos,	–	$32,610 00
Extras for barn, dairy and two silos,	–	4,235 01
Architect's services,	–	3,383 89
Inspector's salary,	–	608 25
Insurance,	–	105 00
Advertising,	–	16 40
Amount of deficit,	3,690 10	–
	$40,958 55	$40,958 55

Dining Hall.

Auditing Sheet.— Fall Semester, Sept. 14–Nov. 30, 1907.

Inventory beginning of period,	$98 69	Inventory close of period,	$1,428 81
Provisions purchased,	3,160 62	Cash extra (transients),	177 79
Outstanding bills,	3,919 98	Balance,	6,916 05
Service, kitchen,	763 11		
Service, table,	580 25		
	$8,522 65		$8,522 65

Total number weeks' board,	1,855
Total cost of board,	$6,916 05
Total cost of board per week,	3 73
Deficit,	$426 65
Deficit previous to July 1, 1907,	2,761 12
Total deficit,	$3,187 77

Funds.

Endowment Fund.

	Principal.	Income.
United States grant,	$219,000 00	$3,650 00
Commonwealth grant,	142,000 00	3,313 00
		$6,963 32

This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Burnham Emergency Fund.

	Principal.	Income.
Two Lake Shore & Michigan Southern Railroad gold notes,	$2,000 00	$50 00
Massachusetts Agricultural College note,	3,000 00	75 00
	$5,000 00	$125 00

Library Fund.

	Principal.	Income.
Five bonds Lake Shore & Michigan Southern Railroad 4s,	$5,000 00	$200 00
Five bonds New York Central & Hudson River Railroad 4s,	5,000 00	200 00
Two bonds New York Central & Hudson River Railroad stock,	200 00	9 00
Amherst Savings Bank,	167 77	10 68
	$10,367 77	$419 68

SPECIAL FUNDS.

Endowed Labor Fund (the Gift of a Friend of the College).

	Principal.	Income.
Two bonds American Telegraph and Telephone Company 4s,	$2,000 00	$80 00
One bond New York Central Railroad debenture 4s,	1,000 00	40 00
Two bonds Lake Shore & Michigan Southern Railroad 4s,	2,000 00	80 00
Amherst Savings Bank,	143 39	7 17
	$5,143 39	$207 17
Unexpended balance Dec. 1, 1906,		213 78
		$420 95
Disbursements for labor,		151 72
Cash on hand Dec. 1, 1907,		$269 23

Whiting Street Scholarship Fund.

	Principal.	Income
One bond New York Central Railroad debenture 4s,	$1,000 00	$40 00
Amherst Savings Bank,	271 64	16 25
Unexpended balance Dec. 1, 1906,	–	42 36
	$1,271 64	$98 61
Disbursements for scholarships,		40 00
Cash on hand Dec. 1, 1907,		$58 61

Hills Fund.

	Principal.	Income.
Northampton Institution for Savings,	$1,180 00	–
One bond American Telephone and Telegraph Company 4s,	1,000 00	$40 00
Three American Telephone Company notes,	3,000 00	171 25
One bond New York Central Railroad debenture 4s,	1,000 00	40 00
One bond New York Central & Lake Shore Railroad $3\frac{1}{2}$s,	1,000 00	35 00
One bond New York Central & Hudson River Railroad gold note, 5 per cent., 1910,	1,000 00	25 00
Boston & Albany Railroad stocks,	362 00	32 58
Amherst Savings Bank,	72 75	3 62
	$8,614 75	$347 45
Unexpended balance Dec. 1, 1906,		939 94
		$1,287 39
Disbursements by botanical and horticultural departments,		99 68
Cash on hand Dec. 1, 1907,		$1,187 51

Mary Robinson Scholarship Fund.

	Principal.	Income.
Northampton Institution for Savings,	$820 00	–
Boston & Albany Railroad stocks,	38 00	$3 42
Cash on hand Dec. 1, 1906,	–	29 33
	$858 00	–
Cash on hand Dec. 1, 1907,		$32 75

Grinnell Prize Fund.

	Principal.	Income.
Ten shares New York Central & Hudson River Railroad stock,	$1,000 00	$60 00
Unexpended balance Dec. 1, 1906,	–	128 74
	$1,000 00	$188 74
Disbursements for prizes,		60 00
Cash on hand Dec. 1, 1907,		$128 74

Gassett Scholarship Fund.

	Principal.	Income.
One bond New York Central Railroad debenture 4s,	$1,000 00	$40 00
Amherst Savings Bank,	11 64	55
Unexpended balance Dec. 1, 1906,	–	40 00
	$1,011 64	$80 55
Disbursements for scholarships,		40 00
Cash on hand Dec. 1, 1907,		$40 55

Massachusetts Agricultural College (Investment).

	Principal.	Income.
One share New York Central & Hudson River Railroad stock,	$100 00	$6 00
Unexpended balance Dec. 1, 1906,	–	21 75
	$100 00	–
Cash on hand Dec. 1, 1907,		$27 75

Summary of Cash on Hand to the Credit of Special Funds.

Hills fund,	$1,187 71	
Investments,	27 75	
Grinnell prize fund,	128 74	
Gassett scholarship fund,	40 55	
Whiting Street fund,	58 61	
Mary Robinson fund,	32 75	
Endowed labor fund,	269 23	
		$1,745 34

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1907. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

AMHERST, Dec. 16, 1907.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Value of Additions to Equipment during the Year ending June 30, 1907.

1. Library,	$1,000 00
2. Apparatus,	7,034 92
3. Buildings,	79,000 00
4. Live stock,	464 00
5. Machinery,	1,497 47
6. Miscellaneous,	750 00
Total,	$89,746 39

II. Receipts for and during the Year ending June 30, 1907.

1. State aid: —	
(*a*) Income from endowment,	$3,896 65
(*b*) Appropriations for current expenses,	42,499 99
2. Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) Additional endowment act of Aug. 30, 1890,	16,666 66
3. Fees and all other sources,	36,267 98
Total,	$106,631 28
4. Federal appropriation for experiment stations, act of March 2, 1887,	$22,000 00

III. Property, Year ending June 30, 1907.

Value of buildings,	$331,775 00
Value of other equipment,	$112,226 59
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60
Value of farm and grounds,	$44,350 00

Number of acres of land allotted to State under act of July 2, 1862,	360,000
Amount of land grant fund of July 2, 1862,	$219,000 00
Amount of other permanent funds,	$142,000 00
Number of bound volumes in library June 30, 1907,	28,000

IV. Faculty during the Year ending June 30, 1907.

College of Agriculture and Mechanic Arts, collegiate and special classes,	32
Number of staff of experiment station,	22

V. Students during the Year ending June 30, 1907.

College of Agriculture and Mechanic Arts, collegiate and special classes,	271
Graduate courses,	8
Total, counting none twice,	279

Gifts, 1907.

The Massachusetts Society for Promoting Agriculture: prizes for dairy school: For best work during the course, three prizes,— $50, $30 and $20. For best butter made by students, three prizes,— $25, $15 and $10. For excellence in stock judging, four prizes,— $10, $7.50, $5 and $2.50.

The Bowker Fertilizer Company, Boston: one-half ton Stockbridge fertilizer as prize in dairy school.

B. von Herff, German Kali Works, New York, N. Y.: one ton kainit as prize in dairy school.

Experiment Station Gifts, 1907.

German Kali Works, New York: one ton each muriate, high-grade and low-grade sulfate of potash.

American Coal Products Company, New York: five hundred pounds of sulfate of ammonia for experimental purposes.

Rockland Rockport Lime Company, Boston: two tons agricultural lime (free from carbonate).

New Jersey Lime Company, Hamburg, N. J.: one-half ton hydrated lime for agricultural use.

Richmond Abattoir, Richmond, Va.: one hundred pounds "Rarva" meat meal.

H. J. Baker & Bro., New York: one bag (four pockets) BB 564 solublized organic material (acidulated leather); one box leather meal.

Coe-Mortimer Company, New York: ten pounds leather meal for experimental purposes.

Henry W. Jeffers, Plainsboro, N. J.: Calculator.

J. B. Knight, Wiscasset, Me.: one hundred and twenty-six varieties of seeds from India.

William Cooper & Nephews, Chicago, Ill.: one pound kale seed for experimental purposes.

Loans, 1907.

Vermont Farm Machine Company, Bellows Falls, Vt.: one No. 5 Separator; one No. 6 Separator; one No. 2½ Turbine Separator.

D. H. Burrell & Co., Little Falls, N. Y.: one No. 2 Simplex Separator.

De Laval Separator Company, New York: one Acme Turbine Separator; one Baby No. 3 Separator; one Baby Separator No. 1.

Sharples Separator Company, West Chester, Pa.: one No. 4 Tubular Hand Separator; one No. 10 Tubular Steam Separator.

Empire Cream Separator Company, Bloomfield, N. J.: one Empire No. 2 Separator.

Stoddard Manufacturing Company, Rutland, Vt.: one 24-bottle Wizard Turbine Tester.

Report of the Farm Department.

I am pleased to report that the farm barn and dairy have been rebuilt, and work in each is in operation. A description and illustrations are included elsewhere in the college report.

The management of the farm has continued along the same lines of work as heretofore, the principal crops being hay, corn and potatoes.

The growing season was favorable to a large crop of hay at first cutting, after which a long-continued drought came, lessening the second cut perceptibly.

Experiments with Nitrate of Soda, High-grade Sulfate of Potash and Phosphatic Slag.

The fertilization of grass lands has been a problem in which we have labored, uniting our efforts with those of the experiment station. In addition to the front fields, which have been regularly laid out to this work for some years, 10 1-acre strips were laid out on the south flat. This was for the purpose of comparing nitrate of soda and sulfate of ammonia, each alone and together with combinations of high-grade sulfate of potash and basic slag. The test was run in triplicate, and large yields were obtained, but not uniform enough to draw conclusions; it is therefore thought best not to report at this time.

The application of fertilizers to the Chester field, Bangs field, south field and front field, together with the rates of yield per acre, are shown in the following tables: —

Chester Field (Pounds per Acre).

Plot.	Nitrate of Soda.	Low-grade Sulfate of Potash.	Phosphatic Slag.	1907.	
				Hay.	Rowen.
1,	150	300	500	5,933	1,366
2,	200	300	500	6,756	1,420
3,	250	300	500	5,518	1,340
4,	–	–	–	1,820	250
5,	175	–	–	2,070	320
6,	–	150	500	2,002	460

Bangs Field (Pounds per Acre).

Plot.	Nitrate of Soda.	Phosphatic Slag.	Muriate of Potash.	1907. Hay.	1907. Rowen.
A,	–	500	150	3,400	938
B,	–	500	150	3,000	1,103
0,	–	–	–	2,090	322
1,	–	500	150	3,500	585
2,	–	500	150	3,726	1,333
3,	150	–	–	3,372	651
4,	150	500	150	6,200	620
5,	200	500	150	6,560	642
6,	250	500	150	5,800	964

South Field (Pounds per Acre).

Plot.	Phosphatic Slag.	Nitrate of Soda.	High-grade Sulfate of Potash.	1905. Hay.	1905. Rowen.	1906. Hay.	1906. Rowen.	1907. Hay.	1907. Rowen.
00,	500	–	150	–	–	–	–	5,158	Not cut.
0,	–	–	–	3,580	168	2,900	760	2,170	
1,	500	150	150	5,943	358	6,004	2,100	5,340	
2,	500	200	150	9,696	510	6,116	2,280	5,740	
3,	500	250	150	12,300	300	6,680	2,570	6,050	

Front Slope Field (Pounds per Acre).

Plot.	Sodium Nitrate.	Phosphatic Slag.	High-grade Sulfate of Potash.	1907. Hay.	1907. Rowen.
1,	–	500	200	3,304	1,343
2,	200	500	200	5,015	1,615
3,	–	500	200	2,487	1,361

Potatoes.

It was planned to devote 9 acres to this crop, — 6 acres in the old fields and 3 on new land in the Durfee pasture. Owing to the excessive rains after the potatoes were planted, those in the Durfee pasture were drowned out. Corn was substituted in their place. The 6 acres in the old fields looked very well throughout the season, and gave an abundant yield of choice eating potatoes.

Corn.

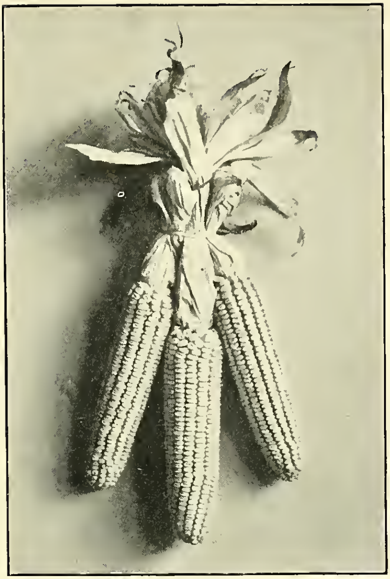
Our Rustler white dent corn has become a leader, maturing as a rule, and giving yields of grain and fodder very large in quantity. It has been our practice to plant the Leaming variety for the silo. This year it failed to germinate enough for a good stand, and consequently we harrowed it up and substituted the Rustler white dent for the second planting. This germinated nicely, making a heavy growth of extra quality corn and a silage that is being eaten well by the cattle.

Analysis of Rustler White Dent Corn Meal.

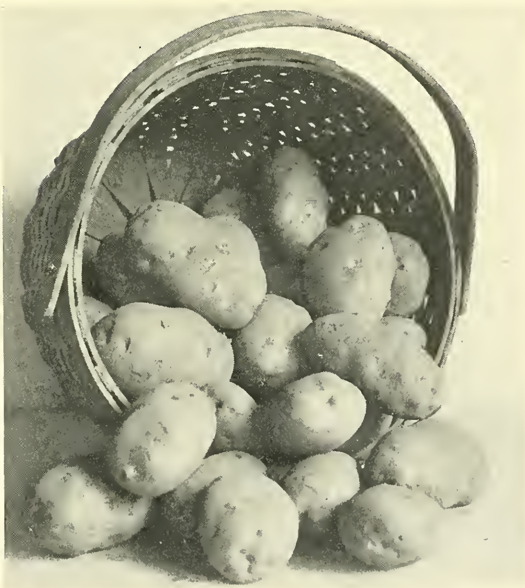
	Sample No. 6101 (Per Cent.).	Average Analysis, Corn Meal for Comparison (Per Cent.).
Water,	11.72	14.00
Ash,	1.36	1.30
Protein,	10.09	9.80
Fiber,	2.03	1.90
Extract matter (starchy),	70.50	69.20
Fat,	4.30	3.80

Manures and Fertilizers for the Several Crops per Acre.

	Rape, 2 Acres.	Field Corn, 8 Acres.	Field Corn, 4 Acres.	Field Corn, 12 Acres.	Field Corn, 3 Acres.	Potatoes, 6 Acres.	Beets, ¼ Acre.	Pop Corn, 3 Acres.
Manure (cords),	–	4	–	–	–	–	–	–
Nitrate of soda (pounds),	125	100	100	100	50	50	50	100
High-grade sulfate of potash (pounds).	150	175	175	175	175	250	175	175
Phosphatic slag (pounds),	600	600	600	600	600	–	600	800
Dried blood (pounds),	–	–	–	–	–	100	–	–
Tankage (pounds),	–	–	–	–	–	200	–	–
Sulfate of ammonia (pounds),	100	100	–	100	100	–	100	100
Acid phosphate (pounds),	–	–	–	–	–	500	–	–



Rustler White Dent Corn.



Green Mountain Potatoes.

Durfee Pasture.

We have continued the work of removing stumps and reclaiming this valuable piece of land, until there are at present 14½ acres that have been subdued. This year 6 acres have been so handled and cropped with corn; 3½ acres that were planted to potatoes last year were planted with pop corn and seeded to grass.

Live Stock.

There are at present on the college farm the following live stock: 21 horses, 39 neat cattle and 68 swine. These are in a generally healthy condition.

The Farm Finances.

The cash receipts for the year are $7,629.46, and there is due on account of sales, made during the year, the sum of $709.34; this added to the cash receipts makes a total of $8,339.80, — an increase of $1,060.24 over the receipts of last year. The inventory at the present time, not including stock, etc., purchased from the special appropriation, is $22,374.62, — a gain of $2,420.83 over 1906. This is accounted for in the growth of neat stock, crops, etc.

The cash received during the year has come from the following sources: for milk and cream, $2,329.01; cattle, $156.75; horses, including fees for use of stallion, $680; swine, $755.81; sheep, $43.47; hay, $1,218.78; potatoes, $190.48; labor, $1,392.62; sundries, $662.54; total, $7,629.46.

The correspondence has greatly increased, over 1,000 letters having been answered by this department during the last year.

E. H. FORRISTALL,
Farm Superintendent.

The New Barn and Farm Dairy.

The barn, stable, silos and farm dairy provided for by legislative appropriation in 1906, to take the place of the building destroyed by fire in November, 1905, and begun last year, have been completed. The plans fronting pages 48 and 49 and the interior views of the cow stable will make the general arrangement clear.

The new building was planned as to most of the details of construction by Edward Burnett and Alfred Hopkins of New York City, in consultation, as to general arrangements as affecting practical adaptation to the uses contemplated, with the professor of agriculture and the farm superintendent.

The storage barn and cow stable are built upon the foundations which served for the building destroyed, and have the same general dimensions and the same arrangement in most particulars. The foundations of the old building were found to have been relatively little damaged, and were put into perfect condition for the new at very moderate cost.

The silos in the old building were under the main roof. In the new they are a part of a separate wing, and are further removed from the stable, — an arrangement more certain to exclude silage odors from the latter, though involving reduced convenience of access.

The Storage Barn.

The south wall (next stable) of the storage barn is of concrete construction; the east end of the wall is of stone to the driveway levels; while the other walls and floors are of the usual timber construction. The door between the stock barn and the stable is fireproof, and closes automatically. The exterior walls, where of wood, are lathed, and these as well as the concrete block walls are covered with lime and cement plaster, with pebble-dash finish. This presents an exceedingly attractive appearance, and is expected to be durable. The roofs are covered with slate.

The dimensions of the storage barn are 140 by 60 feet; the height of the posts is 27 feet; between the upper or machinery floor and the main floor the distance is 21 feet. Without the temporary scaffolds which are planned beneath the upper floor, the capacity for hay is 350 tons; with the scaffolds, which can be filled through traps shown in the upper floor, the storage capacity will be increased at least 25 tons.

Midway between the main and upper floors, and not shown in the plans, is a partial or mezzanine floor. On this floor level is the passage across the east end, a good-sized room for the herdsman, and a grain-mixing room. Below the passage is the root cellar, with capacity of about 9,000 bushels. This is readily filled through traps in the passage floor, while roots are removed for feeding through a door opening into the lower or main floor and near the stable.

Storage for stable absorbents (sawdust or shavings) is afforded by a capacious bin extending from the lower to the upper floor, and filled from the latter; while provision for convenient removal for use in the stable is afforded by the door opening off the lower floor within a few feet of the north end of the stable. On the lower floor level are found rooms for chemical absorbents for stable use, and for barn tools. The upper floor, reached from the outside by an easy grade and affording unequalled facilities for the rapid and economical handling of forage, provides also abundant space for the operation of barn machinery and for the storage of machinery and grain. Such machinery is operated by means of a 20 horse-power motor, which stands near the northeast corner of the floor. On this floor are operated the ensilage and fodder cutter, feed mill, corn sheller, etc. The floored space near the west end on the south side of the center driveway affords opportunity for the convenient turning of teams.

The Silos.

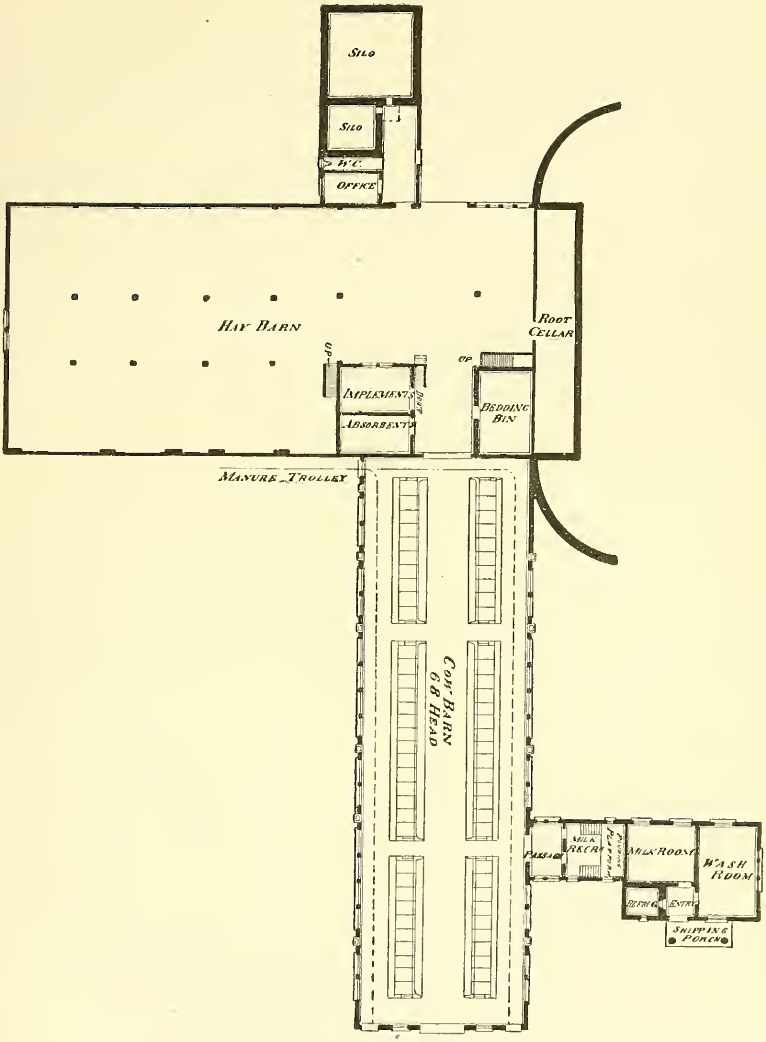
The walls of the wing connecting the silo with the main barn and of the silos themselves are built of concrete blocks. Extra provision for strength in the silo walls was made by bedding a half-inch iron rod between each pair of courses of blocks. These rods extend entirely around the silos, and serve as hoops. The strength is still further increased by putting in belt courses of solid

reinforced concrete. These are relatively close together near the bottom, where the strain is greatest. There are two silos, one 12 by 12 feet, for summer feeding; the other 20 by 20 feet. Both are 43 feet in height. The corners have been made very round and solid, to allow perfect settling of the fodder and to secure abundant strength. The capacity of the smaller silo, with ordinary filling, is about 90 tons; that of the larger, 250 tons. The exterior finish and roofs are like those of the storage barns. The silos are filled through skylights in the roofs by means of a cutter with blower operated on the machinery floor.

Between the silos and the storage barn we have, besides the connecting passage, a toilet room and the herdsman's office.

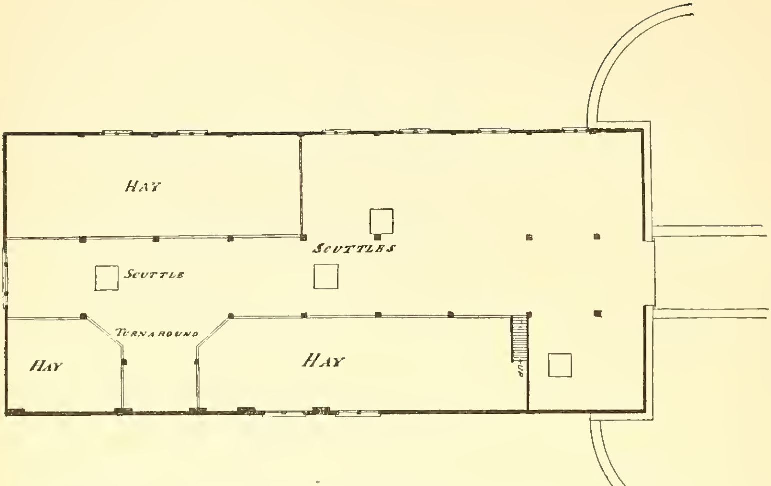
The Cow Stable.

The dimensions of the cow stable extending to the south from the storage barn are 135 by 42 feet. It will accommodate 68 cows, standing in two rows facing each other. The walls are of concrete blocks and the roof is covered with slate. The exterior finish is like that of the storage barns. The stable is provided with large and numerous windows; these swing in from the top, and, being provided with cheeks, serve as Sherringham valves, which act as ventilators in warm or moderate weather. Further ventilation is provided by a modified King system. The essential change from the ordinary King system consists in placing steam pipes in the shafts for outgoing air, thus insuring effectiveness under all conditions of weather. Large vertical shafts which lead directly into the cupolas provide for the escape of heated air. The floors of the stable are of concrete, those beneath and behind the cows being given a rough finish. The mangers, which serve both for water and feed, are also of concrete, the front edge level with the feeding passage, and the lowest point in the bottom on a level with the feet of the cows. The interior walls are of hard plaster, finished in white enamel paint. Both ceiling and floor corners are well rounded, for facility in cleaning. The stall partitions are of bent iron pipes, thus offering the minimum obstruction to light and air. Iron swing stanchions are used in fastening the cows. The manure is removed in cars running on overhead tracks. The stable is piped for hot and cold water and live steam.



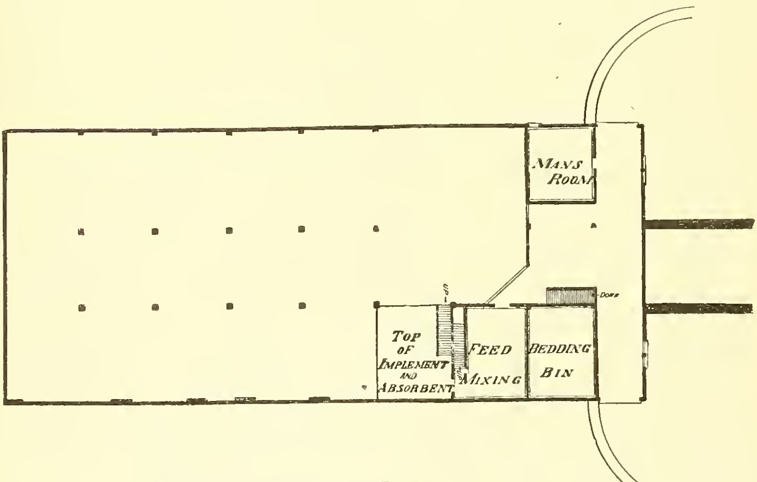
MAIN FLOOR PLAN

SCALE = 16' = 1"

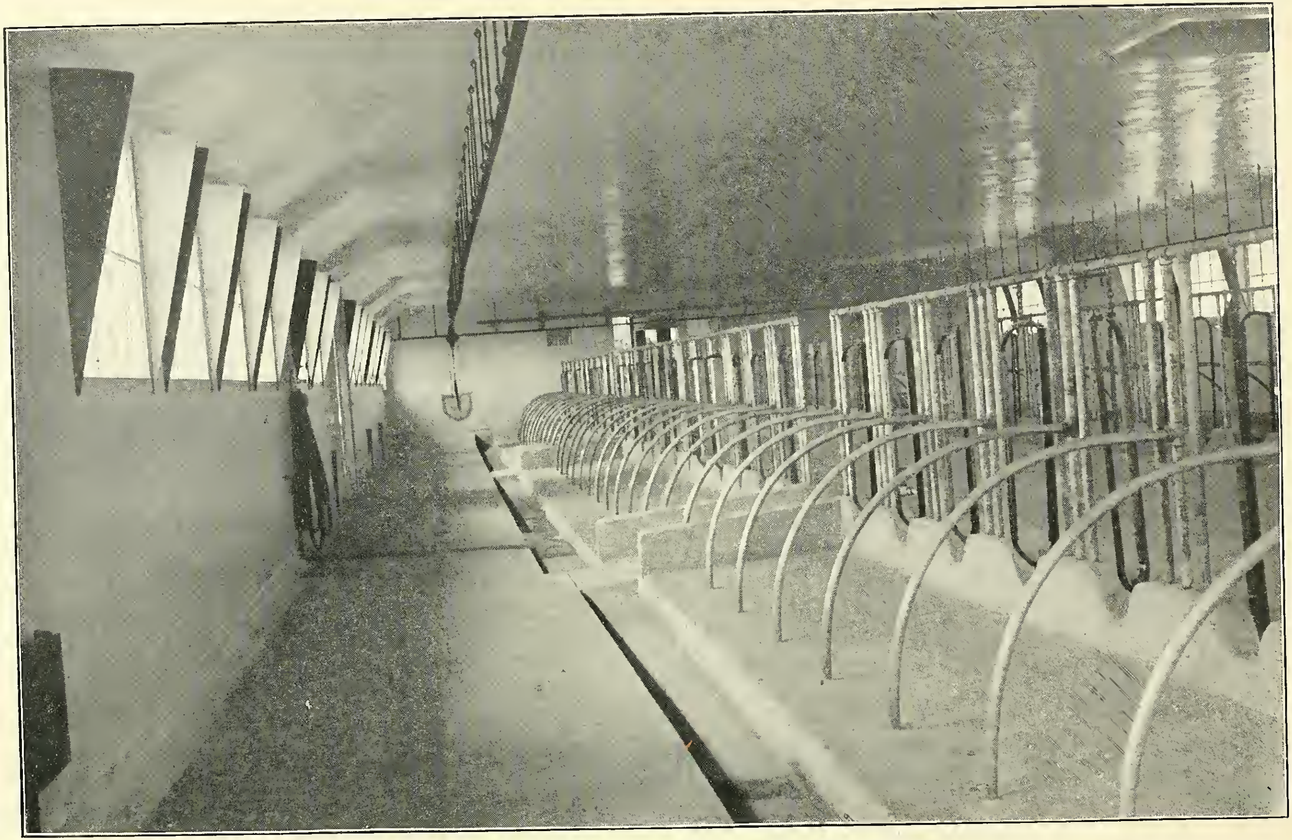


MACHINERY FLOOR PLAN

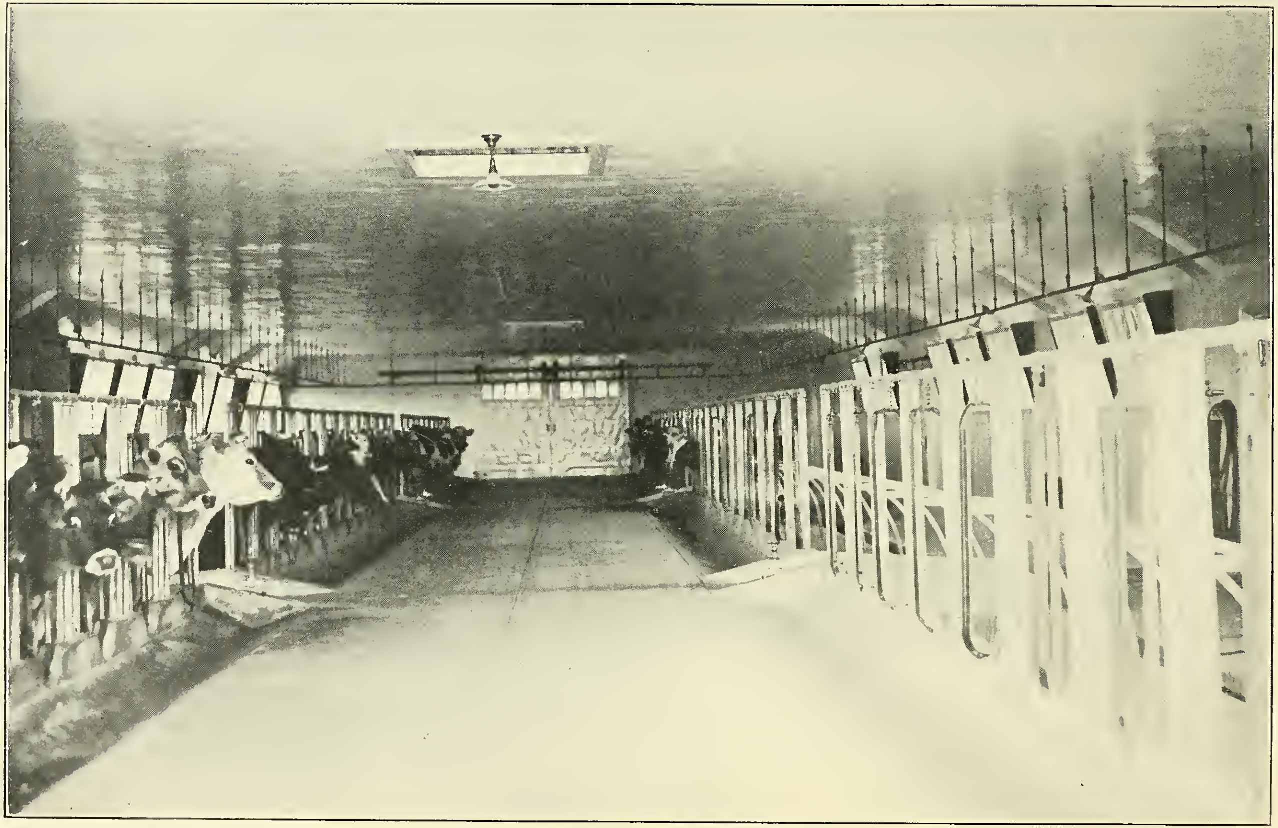
Scale = 16'-1"



MEZZANINE PLAN



COW STABLE. — Rear Passage and Stalls.



COW STABLE. — Feeding Passage.

The Dairy.

In general construction and finish the dairy is like the cow stable. It is connected with the stable by a thoroughly cross-ventilated passage with self-closing doors. Next the passage comes the pouring room. Here the milk will be strained and passed through the wall, either to a cooler or separator, as desired. The cream as separated is delivered over a special cream cooler. Below the coolers stand bottling machines, respectively for milk and cream. The dairy includes, besides the separator and bottling rooms, a thoroughly constructed and well-ventilated refrigerator and a wash room. Set into the wall between the wash room and the bottling room, and with a door opening into each, is a high-pressure sterilizer of large capacity. The wash room contains the most modern form of sink, a bottle washer, Babcock tester and convenient tables and racks. It is believed that the dairy rooms and equipment properly used in connection with the stable afford most excellent facilities for the production of a high grade of milk. It must be possible to produce an article relatively free from bacteria, and with the highest possible keeping qualities.

WM. P. BROOKS,
Professor of Agriculture.

Military Department.

President Kenyon L. Butterfield, *Massachusetts Agricultural College.*

Sir: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 20, 1907.

I have been in charge of the department of military science and tactics since September, 1905, under Special Order, No. 195, War Department, dated Washington, D. C., Aug. 23, 1905. My detail will expire on the first day of September, 1908, making it necessary, soon, to ask for some one to succeed me.

Instruction in this department has been both theoretical and practical, and conducted in compliance with college regulations and War Department orders.

Under the provisions of General Orders, No. 155, War Department, 1907, this instruction is graded, in respect to the military course, as of the second class B, requiring the following minimum of exercises, viz.: —

At every institution of Class B at which a professor of military science and tactics is detailed it shall be provided in its regular schedule of studies that at least three hours per week, or an equivalent of eighty-four hour periods per year for two years, shall be assigned for instruction in the military department, not less than two-thirds of the total time to be devoted to practical drill, including guard mounting and other military ceremonies, and the remainder to theoretical instruction.

The character of instruction will vary according to the nature of the institution and the facilities afforded, but for classes A, B, and C shall include practical instruction in the following subjects: —

(*a*) Infantry Drill Regulations.
(*b*) Firing Regulations for Small Arms.
(*c*) Field Service Regulations.
(*d*) Manual of Guard Duty.

The foregoing subjects will be taken up each year in the order named, and prosecuted as rapidly as is consistent with thorough work and acceptable results. The ground to be covered in each subject will be determined by the

instructor, having in view the size, organization and average age of the military student body, and other limiting conditions.

Theoretical instruction shall include the portions of the above subjects covered by the practical instruction, and may be supplemented by lectures.

In addition to the above requirements of the War Department, additional drills have been given in "Butts' Manual of Physical Drills" and other calisthenic drills. Such additional drills have been held in the drill hall in inclement weather and during the winter season, and have been of great value in keeping the student body in good physical condition.

Commencing with the opening of this college year drill was made elective for the senior class, and the theoretical work has been made a required subject for the junior and sophomore classes, instead of for the senior and freshman classes, as heretofore.

Drill now comes four periods each week, each being for 45 minutes, instead of three periods of an hour each, as in former years. This I believe to be a better plan, as the students get exercise oftener, do not tire of a long drill, and take a greater interest. The drill hour was changed from 3.45 P.M. to 1.30 P.M. Both changes have proved a success, and the majority of students like the change.

As arranged at present, military exercises are conducted in accordance with the following schedule, viz.: —

Drill on Mondays, Tuesdays, Thursdays and Fridays, at 1.30 P.M. Recitation of seniors at 4.30 P.M. on Tuesdays.

Saturdays, inspection of dormitories, including students' rooms, 8.30 A.M.; instruction in guard duty and duties of sentinels, 8.15 to 10.15 A.M. The latter exercise is required only of those students who have incurred demerits in the military department, such as unauthorized absence from drill or inspection, or room not in proper order.

Drills are both in close and extended order; battalion drills are usually preceded by parade and review.

The order of drill commences with small squads in the school of the soldier, and proceeds step by step, with and without arms, until the freshmen become proficient, when they are assigned to the companies, after which the exercises include all movements in company and battalion drill.

The drills are varied as much as consistent with official regula-

tions, to embrace gallery practice (firing indoors at an iron target with a reduced charge of powder, two grains) and the physical drills heretofore mentioned.

In a country like ours, wedded to the policy of a standing army of small size, it seems to me that it is of the greatest importance that our colleges and schools should turn out men with a good knowledge of military science and tactics, so that in the hour of need, we, as a nation, may have some educated men to lead and train the masses. A soldier is of little use if he cannot shoot; hence I believe it to be of the very first importance that the student body at an institution of this kind should be taught to use a rifle and be able to teach others.

Two years ago the target range here was condemned as unsafe. Last year new Krag-Jorgensen rifles were furnished us by the War Department, and this department is now well prepared to take up rifle practice as soon as a range can be built and equipped. I cannot urge too strongly that a range be built at once. This is a subject of the greatest importance. To become a good marksman requires careful study of the mechanism of the rifle, frequent practice upon the rifle range under the various conditions of weather, and daily practice for a few minutes each day in the sighting, pointing and aiming drills, for at least a month before going to the range; this in addition to gallery practice.

The National Board for Promotion of Rifle Practice (established by act of Congress) is now making an effort to establish rifle clubs in all colleges, high schools and private schools of high school grade, and is endeavoring to educate the people to the great need of such clubs.

Recently an ideal site has been found for a target range, — safe, and only about 1¼ miles from the college. This property consists of about 20 acres, and can be purchased reasonably. An option has been obtained on the property until July 1, 1908. The site is also a good one should a week's camp of the cadet corps ever be authorized. I strongly recommend that this property be bought and that a new range be built, with at least three targets; and, if it is possible, that some provision be made by the State whereby tentage and camp equipage be provided which would enable the whole student body to go into camp for one week in each college year, the time to be given to instruction in guard and outpost duty, target practice, construction of shelter trenches, etc.

The band, under the leadership of Mr. Short of Springfield, is in excellent condition, although smaller in number than usual, because of losing six of its members by the graduation of the class of 1907 and gaining only two members from the last entering class. It deserves well all the encouragement that has been given it in the way of appropriations. During the winter months it plays for the calisthenic drills and gives a number of excellent concerts.

All the buildings under my supervision are in good condition except North College. This building should be thoroughly renovated and brought up to modern requirements. Many of the rooms in this building remain unoccupied during the entire year, because students will not remain in them and be put to the inconvenience of depending on one insufficient water-closet and one ancient bath tub. All the rooms in this building having a northern exposure are insufficiently heated, and in some of them a ray of the sun has never entered.

The discipline of the battalion is excellent. During my tour of duty here I have never yet found it necessary to report a student to the faculty for its action.

Absences from drill have decreased each year since I began my duty here, until now they are about one-third less than during my first year. This is due to a strict enforcement of the penalties for such absences, and changing the drill hour to an earlier hour in the day. The number of men excused on doctor's certificate of disability is only one-half as great as in former years, — a result brought about by requiring all so excused to report for clerical and other work, other than drill, during drill hour.

The drill hall is entirely inadequate to the present needs of the battalion. A new and larger one should be erected as soon as it is possible. Six years ago the battalion numbered only 125, and the hall was then too small to do justice to so many; it now numbers 200, and drill is made elective for seniors. The battalion consists of three companies, and the drill hall is hardly sufficient in size to drill one. I manage to keep all busy during the drill period, but I am at times put to my wits' end to know how to do so to the best advantage. I have to make use of the recitation-room, the armory, the gun shed, and last year I often sent several men over to the reading room in North College, now used as the trophy room.

At present students entering college purchase uniforms of some

one of the three leading tailors of Amherst. This is an unsatisfactory arrangement, and more expensive to the student. A few students do not pay promptly for their uniforms. As a remedy, I suggest that each student, when he is admitted to college, be required to make a deposit with the treasurer sufficient to cover expense of uniform, and that all parts of uniform be furnished by the treasury department.

I quote the following from an order of the War Department, dated July 24, 1907: —

> Where practicable, a detailed retired noncommissioned officer shall report to the officer on duty at the school for instructions as his assistant.
>
> He shall be reported by the latter to the president of the school or college, and shall be instructed in his relations to the institution and to its officials.
>
> He shall reside at or near the institution, and shall perform no duties other than those of assistant to the instructor in military science and tactics and acting ordnance and quartermaster sergeant, except by special permission of the War Department.
>
> Retired noncommissioned officers will only be detailed at institutions where an officer of the Army is on duty. Applications for the detail of retired noncommissioned officers must be addressed by the president of the institution to the Adjutant General of the Army, accompanied by a certificate to the effect that the noncommissioned officer will be furnished quarters, or commutation therefor, and extra-duty pay at the rate of at least fifty cents per day, during the period of his detail.

I recommend that the detail of a retired noncommissioned officer to this college be asked for. The expense entailed is small, and in the end I feel that having a noncommissioned officer here would be, instead of being an expense, a saving. He would be of great value in looking after the target range; he would not have to be changed after a period of two or three years; he could take complete charge of the drill hall, look after all rifles and other government property and keep same in good condition; he could raise and lower flag. I am not sure, but do not feel that his doing the janitor work of the drill hall would be objected to. At present the college pays out annually to students nearly $200 for work connected with this department that would be better done by such a noncommissioned officer.

The following-named cadets of the graduating class of 1907 were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown "special

aptitude" for the military service, viz.: Walter Ebenezer Dickinson, John Nicholas Summers, Ralph Jerome Watts, Frederick Charles Peters, Wayland Fairbanks Chace.

The following is a list of ordnance and ordnance stores, property of the United States, in possession of the college: —

2 8-inch mortars, with implements (obsolete).
2 mortar beds (obsolete).
200 Krag-Jorgensen rifles, model 1898.
200 sets infantry accoutrements.
6 noncommissioned officers' swords, steel scabbards.
14 noncommissioned officers' waist belts and plates.
14 sliding frogs for waist belts.
100 paper targets, "A" and "B."
1 set of marking rods, disks and brushes for gallery practice.

All of this property is in good condition and well cared for. Two hundred and seventy-six students have received practical instruction in the military department during the year, some for only a short period, on account of not remaining in college. These figures include the class of 1907.

The organization at present is as follows: one battalion of three infantry companies, and band. Total in military department: 1 major, 4 captains, 6 first lieutenants, 3 second lieutenants, 1 sergeant-major, 1 battalion quartermaster-sergeant, 2 color sergeants, 3 first sergeants, 1 drum major, 15 sergeants, 21 corporals, 137 privates; aggregate, 195.

Respectfully submitted,

GEORGE CHIPMAN MARTIN,
Captain, Eighteenth U. S. Infantry, Commandant.

Testimonial to Professor Goessmann.

As a mark of high appreciation of the forty years' work at this college, which he completed on his eightieth birthday, Professor Goessmann was presented by his former students, at the alumni banquet in Draper Hall on June 17, 1907, with a highly decorated, inscribed window, to be hung in his study. The following remarks were made at that time by Charles Wellington, class of 1873: —

Ladies and gentlemen and fellow students: The fortunate traveller who reaches Frankfort-on-the-Main is at the gateway of a little country whose small area stands in glaring contrast to the greatness of its significance in modern civilization. The city itself bespeaks the hearty, open-handed German welcome which the country beyond extends to the stranger. It is a great center of trade, of chemical industry, of agricultural activity and of artistic life. Aloft, on the noble theater, a monument to Goethe and Schiller, is the guiding motto of this people, "To the Good, the True, the Beautiful."

From Frankfort the journey may be taken over the hills and valleys marked by the sites of Naumburg, Fritzlar, Fulda, Kassel and Göttingen.

Our special guest of to-day was born in Naumburg; Fritzlar was his boyhood home; his ancestors lived in Fulda; Kassel was and is the seat of a grand-ducal government; and Göttingen was his university home.

One of earth's noblest garden spots is this, replete with quiet yet striking beauty, for not only did nature highly endow this countryside, but here also, in general harmony with his Creator, man has wrought for a thousand years. It was here that St. Boniface, the Apostle of Germany, sent by Pope Gregory II. in 718, preached to the old pagan Germans, "die Alten Deutschen," founded the cathedral of Fulda and Christianized the land.

To-day in this Grand Duchy of Hesse are found some of the most important industries of the world, and some of its most refined and intelligent citizens. This region has long been productive of great chemists. Among them was Wöhler, our Professor Goessmann's teacher and lifelong friend; near-by Darmstadt was Liebig's native city; and in Frankfort was born that great chemist, botanist, zoölogist, poet and philosopher, Goethe.

Significant enough is the fact that the crucible which served for centuries in the analyses of the old chemists, and still serves, is called the "Hessian crucible."

The Pope sent St. Boniface to Hesse. Hesse, in turn, after a thousand

years of growth, filled with the missionary spirit, sent two delegations to us. Of these, the first one failed. It was the Hessians of 1775 who, for tainted money, fought against our fathers on the English side. The second delegation came in 1857, and sits with us here to-day, showing a fine example of synthesis or chemical construction; whereas the fate of the first delegation, which went up in smoke, was a good instance of destructive distillation or chemical analysis.

Recent history amply shows that agriculture has advanced in precisely the measure that nature has unfolded her secrets to the persistent, unconquerable keen-witted searchers into the composition of plants and animals and their foods,— that is, to the agricultural chemists. Agricultural chemists, therefore, are the unfolders of modern industrial life, agriculture being its foundation; and their personal history is near akin to the history of agricultural progress.

In a most notable manner our college inherited an agricultural chemist whose scientific pedigree is, and will remain, one of its rarest possessions. The last one hundred years of this pedigree begin with Berzelius. Berzelius was the great chemist of Sweden, who, with Lavoisier of France, was the founder of modern chemistry; Berzelius was the teacher of Wöhler; Wöhler was the lifelong and intimate collaborator of Liebig; Goessmann was the favored pupil, assistant and friend of Wöhler.

It might be well if a brief handy statement, in general terms, of the achievements of these master workers could be made, in a manner to show their progressive contributions to agricultural chemistry. This would also necessarily be a condensed record of agricultural progress in the nineteenth century just gone. The following may be a hint at such a statement: —

In 1808, Berzelius discovered and taught chemical analysis.

In 1828, Wöhler taught chemical analysis and discovered and taught chemical synthesis.

In 1852, Liebig explained chemical physiology and agriculture.

Since 1867, Goessmann has interpreted the meaning of these results in terms of profitable agriculture in America.

If the entire career of the last mentioned may be courteously submitted to analysis, using time as a solvent, it would readily fall into four proximate parts, namely: —

The period before Göttingen, of twenty-three years.

The Göttingen period, of seven years.

The American period, before Massachusetts Agricultural College, of ten years.

The Massachusetts Agricultural College period, of forty years.

The Massachusetts Agricultural College has thus had just one-half of his life, but by far the better half.

By taking another solvent, that of quality of work, the result might be stated thus: —

Theoretical chemistry, chiefly organic, in the Göttingen laboratory; manufacturing chemistry, in sugar from cane at Philadelphia, in salt at Goderich, Canada, and at Syracuse, N. Y., in engineering chemistry at Rensselaer Poly-

technic Institute, Troy, N. Y. A very wide range of study and activity has thus been covered. In the few minutes here allotted it is manifestly impossible to do more than to mention the barest outlines of this work of sixty years. A full discussion of it will be given later.

From the beginning, all of this work, every branch of it, has been prosecuted by continuous and restless research and teaching. Only one vacation has been indulged in,— the year 1899 was spent with the family in Europe. But the irregularities incident to several months of extensive travel proved too great a strain on the steady worker. His health seriously broke down. Months of severe illness were fortunately followed by complete restoration, and since then the schedules of the college and the experiment station have been regularly followed.

Last Thursday, June 13, was "Goessmann Day" with us, for on that day our revered friend sat down before his eightieth birthday cake. An unfortunate discrepancy between the Gregorian calendar and that of the college kept *us* from sharing in the cake before this afternoon. Finally, we are all present to celebrate not only this joyous anniversary, but also the completion of four decades of college service.

Charles Anthony Goessmann, beloved teacher, we now wish to thank you for guiding us to chemical truth, for showing us how to find iron and potash, H_2S and many other such things; but this we could have learned elsewhere. For quite another service we offer you our expression of deep gratitude,— for a gift which we would not have found elsewhere, for rich lessons in that greatest of all studies,— philosophy,—philosophy applied to practical, every-day life and industry. In the old lecture room and in the laboratory these lessons have come to us in rich measure. Oftener yet, when two or three have gathered together in the quiet of evening, early and late, the fruit of your ripe study has been handed down to us during these many years. But this is not all.

In Göttingen to-day and for long years back the professor of "Church History" has been wont to give his listeners, in stentorian tones which floated through the windows into the western world beyond, this formula: "Gentlemen, 'Puritanism' is a disease." Massachusetts Agricultural College men have come to believe that anything from Göttingen must ring true. The three who found their wives there believe so, the nine do who studied higher science there, and also those who found there their theology. And so we believe that Puritanism, like other good things, taken in overdoses must produce disease. Possibly New England was overdosed with Puritanism.

A recently deceased Connecticut divine used to say that "It would have been better for New England theology if, instead of the Pilgrims landing on Plymouth Rock, Plymouth Rock had landed on the Pilgrims." But your remedy was a better one. You brought to Puritan New England a German chemical reagent which, when poured into the bottled-up conservative stiffness here, produced a beautiful reaction.

The result exemplifies the truth of the saying of another Göttingen student, Bismarck, that the Yankees are bound to be the greatest people because they

are to be the greatest mixture of other peoples. This German chemical reagent was "Gemüthlichkeit," — untranslatable, non-transferable German "Gemüthlichkeit." For this we have still yet, immer noch, to thank you

As a mark of our esteem, we ask permission to hang in your study window at home this bit of glass and color, that it may from time to time remind you of the pleasant and profitable bygone days, both in the Fatherland and here with us. On the glass has been written: —

To
Karl Anton Goessmann
of Naumburg Fritzlar and Göttingen
Chemist Teacher Philosopher
this testimonial
commemorative of forty years of faithful and loyal service
at the Massachusetts Agricultural College
is presented by his pupils
on his 80th birthday
June 13 1907

For reminders of the old home places, the armorial bearings of Fulda, Fritzlar and Göttingen are emblazoned, quartered, on one shield; the silver cross of the old arms of Fulda and the lilies of the new; the cross and wheels of Fritzlar and the towers of Göttingen. The seal of the University of Göttingen is shown on the right, with Minerva, the Goddess of Learning, her back toward the spear and the shield bearing the masque of war and facing the emblems of peace, — the olive-branch and the open book. Here is depicted the German chevron, in red, white and black, — the royal and imperial colors. The background shows the Hannoverian color, — yellow, — which also is that of the University.

Below are the emblems of the chemist, the flames of his fire surrounding a Hessian crucible. Here is a retort in ancient form, a blowpipe, assayer's tongs, and before the furnace are test tubes.

The blue and the green of the wistaria are interspersed with the foliage of the arachis or peanut plant and the yellow of its flower, to recall one of your earlier investigations. While at Göttingen you studied the oil of peanuts, the fruit of arachis hypogea, in which you found two acids until then unknown, and which you named "arachic acid" and "hypogeic acid." The luxurious growth of these vines symbolizes the rich harvest due to your labors with fertilizers.

And above has been written the old Göttingen motto, "Die Göttinger haben den Muth" (the Göttingers have courage). The expression originated at the time when the inhabitants of the walled town successfully and successively repulsed the robber barons of the region when on their plunder raids.

Three weeks ago it was the privilege of some here to attend the one hundredth birthday celebration, at Harvard, of Louis Agassiz. Though considerably older than yourself, his name has been much linked with yours in our minds, because of your common interest in education, in questions of chemical geology, and *because he was largely instrumental in your coming to this college.*

Unfortunately, Agassiz was not present on that occasion, except in spirit, for at the early age of seventy-three he had gone over with the old boatman of the Styx. But he was a naturalist, — chemists are of a longer lived race. The chemist Chevreul was an active participant at his one hundredth birthday festivities, when the entire city of Paris turned out to do him honor. The credible rumor has come to us that you have joined Dr. Wiley's one hundred-year club. We are told that on entering this club each man pledges himself to live one hundred years and that any one who dies before this appointed age is expelled from the club in disgrace. Of your membership in this club we are glad to know, and be assured that, as the entire city of Paris turned out to do honor to Chevreul, so will we all be on hand to celebrate your centenary. At one hundred Chevreul was voted the ownership of the city, but at eighty you own us all. We wish you, our noble Hessian, many happy birthdays more.

Massachusetts Conference on Rural Progress.

Amherst, Oct. 2–5, 1907.

Oct. 2, 1907, was the fortieth anniversary of the opening to students of the Massachusetts Agricultural College. The college desired to celebrate in some adequate fashion this important event in its history, and decided to hold at the college a meeting lasting four days, with a program of subjects devoted to rural affairs which should attract the attention of all who are in any way interested in rural matters. Practical farm topics were discussed. Country churches and rural schools were considered. Village improvement was taken up. So far as possible, all phases of rural life had a part in the plan.

The idea lying back of this manner of celebrating the college anniversary is that the Agricultural College stands as a sort of clearing-house, a leader, in rural betterment. If the Agricultural College does its duty, it will make a study of all phases of rural life, and it will assist, so far as any college can, all movements for the betterment of rural life. It was believed that a Conference on Rural Progress, covering the whole field and bringing together the representatives of all rural interests, was a most appropriate method of celebrating the forty years of work which the college has achieved. The historical and anniversary aspects were not disregarded, but the outlook was toward the future.

PROGRAM.

Wednesday, October 2.

Forenoon Session, College Chapel, at 10.

Chairman, Dr. Edward Hitchcock, Amherst.

Anniversary Program.

The Beginnings of College History, — Hon. M. F. Dickinson, Boston.

The "Old Guard," the Famous "Faculty of Four," and our Debt to Amherst College, — Mr. William H. Bowker, Boston.

The Massachusetts Experiment Station, — Director William P. Brooks.

Afternoon Session, College Chapel, at 2.

Chairman, Carlton D. Richardson, North Brookfield.

Some Features of New England Dairying,— Prof. C. E. Beach, University of Vermont, Burlington, Vt.

Discussion.

The Grange and Rural Progress,— Hon. N. J. Bachelder, former Governor of New Hampshire, and Master of the National Grange.

4 p.m. Dedication of Clark Hall,— Addresses by David P. Penhallow, D. S., Professor of Botany, McGill University, Montreal, Can.; John M. Tyler, Ph.D., Professor of Biology, Amherst College.

Evening Session, Town Hall, at 7.30.

Chairman, Hon. Marquis F. Dickinson, Boston.

The Broad Outlook of the Agricultural Experiment Stations,— Dr. A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.

The Value of Art and Skill in Industry,— President Carroll D. Wright, Clark College, Worcester, Mass.

Thursday, October 3.

Forenoon Session, College Chapel, at 9.45.

Chairman, Hon. J. Lewis Ellsworth, Boston.

The Forestry Situation in Massachusetts,— F. William Rane, State Forester, Boston.

Discussion.

Co-operation in the Marketing of Fruit Products,— Prof. John Craig, Cornell University, Ithaca, N. Y.

Discussion.

10 a.m., Section Meeting in Clark Hall,— Conference of College students on County Y. M. C. A. work.

Afternoon Session, College Chapel, at 2.

Chairman, Edward T. Hartman, Boston.

Round-table of the Village Improvement Department of the Massachusetts Civic League,— "Getting Together, the Fundamental Concept," G. L. Munn, Easthampton; "The Place of Systematic Planting in Improvement Work," Edward Canning, Northampton; "An Eight-minute Survey of Eighty Years," Christopher Clark, Northampton; "One Year of the Civic League of Greenfield," Herbert C. Parsons, Greenfield; "Easthampton's Contribution," Prof. J. H. Sawyer, Easthampton.

The Grange and Village Improvement,— Charles M. Gardner, Lecturer of the Massachusetts State Grange, Westfield.

2 P.M., Section Meeting in Clark Hall, — Conference of Officers County Y. M. C. A. work.

4.30 P.M., Concert by the College Band.

Evening Session, Town Hall, at 7.30.

Chairman, Prof. GEORGE D. OLDS, Amherst.

The Country Boy in Service, — Mr. John R. Boardman, of the International Committee of the Y. M. C. A., New York, N. Y.

Interpretation of the Civic Improvement Campaign in America, — Henry Turner Bailey, Worcester, Mass.

FRIDAY, OCTOBER 4.

Forenoon Session, Clark Hall, at 9.45.

Chairman, Dr. WILLIAM P. BROOKS, Amherst.

The Care of Shade Trees, — Dr. George E. Stone, Massachusetts Agricultural College, Amherst.

Discussion.

Some Poultry Questions, — Prof. G. M. Gowell, University of Maine, Orono.

Discussion.

11 A.M., Section Meeting of the Western Massachusetts Library Association, in the College Chapel.

Afternoon Session, College Chapel, at 2.

Chairman, WILLIAM I. FLETCHER, Amherst.

The Public Library as a Means to Rural Betterment, — Mr. William R. Eastman, Chief of the Division of Educational Extension, New York State Education Department, Albany.

The New Rural Life, — Rev. Wilbert L. Anderson, Amherst, Mass., author of "The Country Town."

3.30 P.M., Dedication of Athletic Trophy Room by the students of the Massachusetts Agricultural College.

Evening Session, Town Hall, at 7.30.

Chairman, Rev. HENRY LINCOLN BAILEY, Longmeadow.

Light on the Problem of the Country Church, — Rev. John Calvin Goddard, Salisbury, Conn.

Discussion, — Rev. F. E. Emrich, Boston.

The Front Line of Country School Improvement, — Illustrated Lecture by O. J. Kern, Superintendent of Schools, Winnebago County, Rockford, Ill.

SATURDAY, OCTOBER 5.

Forenoon Session, College Chapel, at 9.45.

Chairman, Prof. FRANK A. WAUGH, AMHERST.

The New Agriculture in the Country School,— Illustrated Lecture by O. J. Kern.

What Agricultural High Schools are doing,— Dr. K. C. Davis, Dean State School of Agriculture, St. Lawrence University, Canton, N. Y.

Afternoon Session, College Chapel, at 1.30.

Chairman, Supt. A. L. HARDY, Amherst.

The Problem of Industrial Education,— Charles H. Morse, Secretary of the Massachusetts Commission on Industrial Education.

Some English Experiments in Agricultural Education,— Hon. George H. Martin, Secretary of the State Board of Education.

THE BEGINNINGS OF COLLEGE HISTORY.[1]

It is not always easy to touch the sources of controlling influences. The head of the spring may be, generally is, somewhat remote from the spot where its sweet waters emerge upon the surface. It would be impossible to discover among the northern hills the tiny lake which is the very head water of yonder broad Connecticut. These analogies hold as to educational movements and institutions. We may trace back the history of the world's oldest and greatest centers of learning until our quest is lost in the dimness of tradition; but even then perhaps we shall not reach their real origin. National enthusiasms, religions, even wars, patriotic inspirations, social movements, the benevolence of individuals and communities,— all have played their effective parts, under varying conditions and circumstances, in enlarging the boundaries of educational influence and power. And so it happens that in the last analysis it may be impossible for me to state exactly what particular influence most effectively contributed to the establishment of the institution which forty years ago to-day threw open its doors to the aspiring young men who constituted its first entering class. No man can tell just where lay the one efficient, creative cause of our college life, nor exactly who proposed the seed thought out of which has grown modern agricultural education and the Massachusetts Agricultural College, whose fortieth festal day we are here to celebrate. I say all this, not forgetting the great Morrill act of 1862, upon which the superstructure of our college life is laid. It would be difficult, perhaps impossible, for any man to corral in a single statement, however full, all the sources of our existence. The most that can be done in the half hour allotted me is to point out the particular influences and the particular men that impress me as the most conspicuously prominent in laying our foundations.

The war of the American revolution left the thirteen colonies exhausted and

[1] Read at the fortieth anniversary of the opening of the Massachusetts Agricultural College, Oct. 2, 1907, by M. F. Dickinson, Esq., of Boston.

poor. Education was at a low ebb; the ambition of our hardy New England yeomanry was well-nigh crushed out under the adverse conditions created by a depreciated currency and universal bankruptcy, which seemed to threaten our rural communities. The breaking out of Shay's rebellion here, similar political disturbances elsewhere, and the feeling of universal unrest and dissatisfaction prevalent among the common people of most of the colonies, were ominous signs of great national peril. The exigency compelled the establishment of a central government and the adoption of a federal constitution as the only remedy from anarchy and the loss of free institutions. When the head master of the Boston Latin School heard the news of Lexington, he sent the boys home, declaring, in the prevailing doggerel style of the time: "War has begun and school is done." From the opening of the revolutionary struggle until its results were garnered up by the Constitutional Convention of 1789 there was not a moment of national security. When the work of that convention was accepted by the States, then was guaranteed to America the indissoluble union of the federal States and the immortal perpetuity of federal powers. The establishment of an orderly government at once enlarged the outlook and stimulated the aspirations of the people everywhere. Hope took the place of discouragement, business enterprises began to prosper, and the faces of all men seemed to be turned toward the morning of a new day of greatness and glory. With this material improvement came a new mental alertness which everywhere took possession of the nation; and in the development which followed, the cause of education secured its full share of betterment. The future welfare of the country, and of the *whole country* as distinguished from the separate States, became a subject of intense interest and speculation. It began to be understood as never before that the agricultural resources of the United States would prove in the end the greatest of all its assets, and accordingly ideas and plans for agricultural improvement began to press upon the minds of thoughtful and patriotic citizens.

It is interesting to note that the indications of an enlarged and more intelligent interest in agriculture, and of the importance of more widely disseminated knowledge on farm subjects, first appeared in the principal centers of population. This is the point from which I trace the first important influence among the beginnings of college history, to which I wish to refer.

In the year 1792 the Legislature of Massachusetts incorporated the Massachusetts Society for Promoting Agriculture. This ancient organization is still in existence, fulfilling its unselfish mission after one hundred and seventeen years of patriotic and fruitful service. No other single organization in New England contributed so much in the earlier periods to the advancement of agricultural knowledge; no other has given so strong an incidental impulse to the cause of agricultural education. In 1792 few societies of agriculture existed anywhere. Great Britain had only two,— one in Dublin, a small affair, the other in Scotland,— for the British Board of Agriculture was not created until 1793. So far as America was concerned, efforts in this direction seem to have been confined to the States of New York and Pennsylvania and one or two of the Canadian provinces; but the Massachusetts society of which I speak

was the first on the continent to receive legislative sanction and formal incorporation. It was called into existence by citizens of the highest distinction and influence. At the head of the original incorporators stood Samuel Adams, the great colonial leader; Gen. Benjamin Lincoln, who received the sword of Cornwallis at Yorktown; Thomas Russell, one of the merchant princes of Boston, once the owner of the Vassall estate at Cambridge, which we now cherish as the home of Longfellow; Charles Bulfinch, the famous architect who designed our venerable State House, and was architect of the Capitol at Washington as originally constructed; Christopher Gore, distinguished legislator and diplomatist, United States Senator and Governor of Massachusetts, benefactor of Harvard College to the extent of $100,000, — a great gift for that day; John Lowell, the distinguished jurist, member of the Massachusetts Constitutional Convention of 1780, where he secured the abolition of slavery in our State by the insertion into the constitution, in our declaration of rights, of the statement that "all men are born free and equal" (thus extending the thesis of Jefferson in the great declaration that "all men are created equal"), afterwards judge of the district and circuit courts of the United States; Samuel Phillips, founder of Phillips Andover Academy; James Sullivan, afterwards Attorney-General and Governor of Massachusetts; and others almost equally distinguished. All those whom I have especially named, save one, were graduates of Harvard College. Soon after its organization other great names were added to its membership, — John Hancock, John Adams, Fisher Ames, Gen. Henry Knox, Gen. William Heath, Gen. Artemas Ward, all of revolutionary service and fame; Governor Levi Lincoln, Loammi Baldwin, Josiah Quincy, George Cabot and Theodore Lyman. In later years its roll has included many of the leaders of the State, — governors, judges, senators and Congressmen, scholars and men of science, great merchants, capitalists and philanthropists. Its president to-day is the renowned scientist, Charles S. Sargent; its efficient secretary, the accomplished and genial Gen. Francis Henry Appleton, for some years a most useful member of our Board of Trustees. Large sums of money have from time to time been bestowed upon it in the way of gifts, so that it has enjoyed unusual opportunity to extend its sphere of useful service. None of its officers have ever received any salary, nor has the society ever spent any money for the entertainment of its members or its guests. It has contributed to the world a noble example of unselfish public service.

The art of agriculture was indeed at a low ebb when the society entered upon its philanthropic work. The real value and proper use of manures were largely unknown. We are told that occasionally barns were removed from their old locations to get them away from long-accumulating heaps of dung. Agricultural implements were rude and imperfect. Crops were few in variety, carelessly planted, indifferently cultivated and unintelligently harvested and housed. Live stock, horses, cattle and sheep, were of inferior grades, and were cruelly neglected and uncared for. Agricultural implements were of ancient and ineffective types. The hours of labor were inordinately long. All work seemed to be done in the hardest way. The fitness of a particular field

for a special crop was quite a matter of indifference. The practice of the grandfathers and early settlers still held the New England farmer fast bound to traditional and worn-out methods. To these deplorable conditions the new society offered the light of intelligence and the hope of improvement. But it was slow work to overcome the prejudices and practices of a hundred and fifty years. It was hard to persuade the country farmer that he ought to open his eyes to the improved methods which were beginning to appear in Europe. The reformers were ridiculed as "gentlemen farmers" and "book men," who were attempting changes quite unsuited, it was thought, to requirements of the practical husbandman. At the end of its first quarter-century President Lowell admitted that during its first years the society did not accomplish much good; but added that it was not the fault of its founders, for they were ahead of the public opinion of their age. They had invited, with rather unsatisfactory response, the co-operation of farmers by valuable series of questions sent broadcast throughout the State, asking for information as to existing conditions and wants in rural communities. But indifference and ridicule did not dishearten these apostles of the new era. They began to talk about an experimental farm, and thus created an interest out of which finally grew the Botanical Garden at Cambridge. Generous members and their friends began the endowment of the society, and soon prizes began to be offered for essays and papers on practical agricultural subjects. The first one taken up was that of compost manures. The canker-worm pest, the drainage of ponds, the methods of maple sugar making, butter and cheese production, the proper care and treatment of sheep, the cultivation of wheat and onions, the analysis of soils, the necessity of improved ploughs, were among the subjects urged upon the attention of Massachusetts farmers during the first decade of the society's history. An impression finally began to be made. It was at length evident that the organization was going to justify its claim to be considered an important factor in enlarging and extending the boundaries of agricultural knowledge.

In 1801 the society began a series of fairs at Brighton, where it finally purchased land and erected an agricultural hall for the uses of its annual gatherings. These were kept up until after 1830. Following its example, agricultural societies quickly sprang up all over the State, until the "fall cattle show" became one of the recognized features of New England life, — a kind of organization which shortly after 1850 led up to the establishment by our Legislature of our excellent Board of Agriculture, to the influence and aid of which, through its intelligent and progressive membership, the Massachusetts Agricultural College owes so much. Without its loyal support the college could hardly have weathered the stormy period of legislative criticism and hostility through which the institution passed during the later period of President Clark's administration and that of his successor, Mr. Stockbridge. Its forty members constitute a most powerful and effective influence at the State House when they unite upon or against any proposed legislation which vitally affects our agricultural communities.

In 1813 the society had accumulated, from gifts, a permanent fund of $20,000; and the following year the Legislature made it "a liberal grant" of $1,000

annually from the State treasury, for circulating its publications, for conducting experiments and for the other useful purposes which it was endeavoring to promote. The same year began the publication of its semiannual serial, "The Massachusetts Agricultural Journal," which was succeeded years later by "The New England Farmer" as its semiofficial organ. Thus at length came the era of agricultural newspapers, the educational features of which to-day constitute a most valuable contribution to the progress of Massachusetts agriculture.

As early as 1824 the society was asked by the trustees of Dummer Academy at Byfield, in old Newbury, to join them in conducting an experimental farm on the extensive lands of that ancient school. The trustees of the society heartily approved the movement, but declined the proposal because they thought such an enterprise ought to be controlled and cared for by the State rather than by a private corporation. In this proposal we distinctly discover the germs of our modern agricultural educational system.

In the evolution of the modern plough, which seems to be the outgrowth of Jefferson's early invention, this society took a leading part. Its annual ploughing matches at Brighton had in view not so much to test the skill of the ploughman as to discover the best and most effective instrument. Its liberal premiums in this department did much to encourage manufacturers of agricultural implements in perfecting this most indispensable and important servant of the practical farmer.

Early in its history the society had turned its attention to animal husbandry. By liberal premiums bestowed at its own and county cattle shows it had encouraged the importation of foreign breeds by individuals; and by its own importations from time to time had encouraged the practice. In this way, beginning with the year 1816, have been brought from abroad, partly by private enterprise, but largely with funds furnished by the society, of horned stock, Alderneys and Ayrshires, Devons, Flanders, Holderness and Portuguese cattle; Short Horns, Herefords, Holsteins, Guernseys and other valued strains; Leicester, Arabian and Russian sheep and many other valuable kinds from Great Britain and elsewhere; shapely swine, fitted to replace our long, lean, lank and limber native stock; and horses of superior quality, notably the huge Percherons, which have proved of great value in improving the race of farm and team horses. This service has been rendered at large expense; for these imported animals after having been kept for considerable periods for public use, have been finally sold much below their cost, and thus distributed throughout the State among farmers and others interested in improving our lines of stock.

In 1836 the society joined in a movement to secure what was called an agricultural survey of the State, which led to the appointment of Rev. Henry Colman of Deerfield, of whom I shall speak later, a well-known agricultural expert, for this service. It is interesting to note how much good work has been done by the clergy in the uplift of agricultural interests. Many of you will recall in this connection the admirable paper prepared, and many times read before interested audiences, by our lamented Goodell, entitled "The

Influence of the Monks in Agriculture." It was a piece of original work that deservedly received the highest praise, and ought to be permanently preserved in print.

The introduction and improvement of the mowing machine engaged the special attention of the society in the fifties; the importation of English harrows, a study of the ravages of the potato bug, the planting of forest trees, helpful service rendered to the Bussey Institute in its beginnings and to this young and ambitious college in its early days, were among some of the important services rendered in the seventies. I note an interesting fact, that once it made a donation of $200 to an ingenious Agricultural College student, to aid him in perfecting a steam plough of his own invention. The sequel I have not discovered. Who will write the obituary of that steam plough?

But time fails me to recount all the great services rendered by this ancient society to the cause of agriculture, and the inspiration it has given to the cause of agricultural education. As friends of the college we desire to-day to recognize with especial gratitude, by this somewhat extended notice, the profoundly important influence, partly active, partly indirect and incidental, exerted by it from first to last in helping to lay on sound and permanent foundations the Massachusetts system of agricultural education. The analogy between its exertions and the later and broader work of our United States Department of Agriculture, which has now grown to be one of the great universities of the world, can hardly have escaped your attention, as I have imperfectly sketched the achievements and influence of this beneficent organization.

In 1820 Andrew Nichols, at the first show of the Essex Society referred to the fact that Governor De Witt Clinton of New York State had recently declared himself in favor of the establishment of agricultural schools for the purpose of improving the art of husbandry, and himself expressed the belief that established agricultural academies, well endowed and managed, would prove of the greatest benefit to the State. Fourteen years later we find Mr. Mosely urging similar news before the same society, claiming for agricultural education equal rank with establishments for military and naval training. A serious attempt was made in 1824, aided by the Massachusetts Society for Promoting Agriculture, to create at Dummer Academy an agricultural department; but the aid sought from the Legislature to enable the institution to launch the scheme was withheld. Colman, in one of his reports made in the early forties, refers to a similar attempt to locate an agricultural school at Beverly, where land had been already bought for the purpose. In 1840, at the Teachers' Seminary on Andover hill, which had then existed some ten years, a course in scientific and practical agriculture was announced, and the teacher of mathematics was entrusted with its care. This institution was soon merged with the scientific department of Phillips Academy, where all agricultural features were soon lost except the farm, which I believe is still a part of the academy property, and is devoted to golf links. Westfield Academy had a legacy of $5,000 from Stephen Harrison in 1856, which was to become available when the additional sum of $5,000 could be secured. This benefactor was evidently the precursor of Mr. Pearson of Chicago, who has so

effectively used this plan of giving to colleges in our own day on the offer, "So much from me, if others will contribute an equal amount." I am unable to tell you what results followed this Harrison bequest. Powers Institute of Bernardston just before 1860 was conducting a course in agriculture, and vainly asked aid from the Legislature for the purpose of expanding the work. Our General Court generally has been shy about affording aid to academies. In 1842 Benjamin Bussey died, leaving a large foundation, not then immediately available, for the establishment of the Bussey Institute of Agriculture. Our college was at the outset in danger of becoming merged with it, in which case we should probably have been to-day an adjunct of Harvard University.

One of the most eccentric of wills was that of the late Oliver Smith of Hatfield in our own county of Hampshire. My characterization of the instrument would, however, convey a wrong impression if I did not add that it established a number of very original and noble trusts. It created the institution we call the "Smith Charities," and is a blessing to the inhabitants of eight of these river towns,— five in Hampshire and three in Franklin. Mr. Smith was a bachelor farmer, called wealthy in those days, though he left what would be nowadays only a competency,— hardly enough to pay the necessary, or rather unnecessary, expenses of a modern millionaire for a single year. He had lived a frugal and thrifty life, and had grown legitimately forehanded by letting out money at interest. He had mastered the problem of "the accumulating fund." And so the charities he created were, to a large extent, to become available long years in the future. The will was made in 1844. Mr. Smith died in 1845. Then ensued a notable contest, in which some of his heirs attempted to set the will aside on the ground of the insanity of one of the attesting witnesses. Chief Justice Shaw, the greatest of Massachusetts jurists, presided at the trial; Samuel Williston of Easthampton was foreman of the jury; Daniel Webster and Rufus Choate were counsel for the executors and the contestants respectively. The trial took place in the old court house in Northampton. Mr. Choate urged the case against the will a large part of one entire day; Mr. Webster spoke only twenty minutes. The instrument was sustained by the jury, and the full bench of the Supreme Judicial Court confirmed their finding. Undoubtedly it was his service as juryman in this case which suggested to Mr. Williston some provisions of his own will, made more than a quarter of a century later, wherein the same feature of large "accumulating funds" for educational purposes appears in the liberal provision made for Williston Seminary. Mr. Smith's foundation provided that the sum of $200,000 was to be held by the trustees until it had doubled; then the fund was to be divided into three portions,— $30,000 for an agricultural college at Northampton; $10,000 for the American Colonization Society; $360,000, to be called the joint or miscellaneous fund, for the benefit of indigent boys, indigent female children, indigent young women and indigent widows of the eight towns before referred to. The residue of the estate went to a contingent fund, by ingenious provisions intended to secure and enlarge the miscellaneous fund. The $30,000 agricultural fund the trustees were to continue to hold until the expiration of sixty years from the testator's death, and then to pay it over to the town of North-

ampton for the establishment in that town of "Smith's Agricultural College." This fund became available, under the terms of the will, in 1905. Lands have been purchased and plans are maturing for the erection of buildings for the instruction of boys in agriculture and the mechanic arts. I have gone into considerable detail in dealing with Mr. Smith's will, because this college is vitally interested in the success of the Northampton institution. Each should be helpful to the other, and somehow the work of each should be made to strengthen and supplement the work of the other. The field is wide enough for both. It is quite likely that if Mr. Smith had lived twenty-five years longer the provisions of his will might have been somewhat modified to suit later conditions. But a testator has a right under the law to legislate as to the disposition of his estate after his death, and his will ought to be executed as written, except as to such provisions as are unlawful or contrary to public policy. No such flaws are to be found in the will of this shrewd Yankee yeoman; so that on this festal day the Massachusetts Agricultural College sends its hearty greetings and best wishes to its neighbor and colleague beyond the meadows and the river. It is an interesting fact, worth noting here, that Miss Sophia Smith, founder of Smith Academy at Hatfield and of Smith College at Northampton, was a kinswoman of Oliver, and actuated by similar benevolent motives.

Another educating influence along agricultural lines was the work done by Rev. Henry Colman of Deerfield. He was an accomplished preacher of the Unitarian denomination, with whom agriculture was a delight and passion. He was graduated from Dartmouth College in 1805, in the same class with Francis Brown, whose presidency of that institution included the period when the celebrated Dartmouth College case was passing through its various stages, and in which Daniel Webster, a loyal son of the college, won his greatest professional triumph before the greatest of the chief justices in the Supreme Court of the United States. After leading the life of a teacher and preacher for more than thirty years, Mr. Colman was commissioned by our General Court in 1837 to make a complete agricultural survey of the State, and to report results to the Legislature. These reports, four or five in number, cover a period from 1837 to 1841, when his work was discontinued, for reasons not fully explained. The survey included the counties of Essex, Middlesex, Berkshire and Franklin, and are full of interest, even now. They indicate great intelligence and skill in investigation, are models in style, and will repay examination by the ambitious student of to-day. They may be found, I believe, in our excellent library. Mr. Colman travelled extensively in Europe upon this business, where he received great attention from many distinguished men, and became socially popular, being of fascinating person and deportment. He died suddenly in London in 1849. He too was an apostle of agricultural education, and with untiring zeal urged its extension. In summing up the most notable influences which contributed to the growth of public sentiment among our people on this subject from 1820 to 1860, his name deserves a prominent place.

After 1840 the interest in the subject of agricultural education was greatly heightened. Everywhere, at county fairs, in the people's lyceums, and by re-

peated petitions to the Legislature, the matter was kept constantly before the people. A notable utterance was contained in Governor Briggs's inaugural address of 1850, out of which grew the resolves of that year looking to the establishment of an agricultural school in Massachusetts. The appointment of commissioners to investigate and report upon the subject, among whom were Mr. Wilder and the elder Edward Hitchcock of Amherst College, followed, but the effort proved unsuccessful. I omit anything more than a reference to that college and Dr. Hitchcock's work, because that subject is to be treated at some length by my friend Mr. Bowker, who is to follow me.

More than to any other man we owe a debt of gratitude to Marshall P. Wilder, whose name stood at the head of the first Board of Trustees of this college, and who was, from the time of its organization to the day of his death, always the staunch and tried friend of the institution. As far back as 1849, in an address before one of our agricultural societies he strongly advocated the establishment of schools where theoretical and practical agriculture should be taught.

In 1856 was incorporated the Massachusetts School of Agriculture, Mr. Wilder again heading the Board of Trustees. In 1860 the charter of this corporation was transferred to several citizens of Springfield, who undertook to raise $75,000 to carry out its objects, expecting to receive from the Legislature further endowment; but the civil war interfered with their plans, and the effort proved abortive.

It was under the stimulus of these various institutions for better farming and better education therein that the State Board of Agriculture came into existence, by act of the Legislature, shortly after 1850. It was composed of three delegates from each of the incorporated societies in the Commonwealth, and has always constituted an influential body of citizens. Its objects were stated to be "the encouragement of agricultural education and the improvement of agriculture in all its departments in this Commonwealth." There has been a very close connection between that institution and this from the time of our foundation to this moment, and it ought to be said that the Board has always been a staunch friend and supporter of the college.

It was a strange circumstance that, after all the efforts made to secure action by our own Legislature for the establishment of an agricultural college, the institution at last came to the State as a benefaction of the general government. Senator Justin T. Morrill of Vermont — a name always to be spoken in honor by men of our faith — had been for years urging the distribution of large portions of the public domain among the States for purposes of education in agriculture and the mechanic arts. During the administration of Mr. Buchanan his efforts were partially successful. Congress indeed passed the act, but the bill was vetoed by the President. Mr. Lincoln was more friendly to the movement; Congress re-enacted the bill, the President set his approval upon it, and it became a law July 2, 1862. This was the beneficent Morrill act, under which sixty-five colleges have come into being in the United States. The sums bestowed upon the respective States were in proportion to the number of senators and representatives. Thus Massachusetts ultimately received about $360,000. Under the law, one-tenth could be used for purchase of land, none

of it for buildings. The States were required, through their Legislatures, to accept the benefits of the act within two years from its passage, and to provide within five years thereafter not less than one college, or the grant to the State should cease. It is well known that through the agency of its influential friends the Institute of Technology secured the income of one-third of the $360,000, and thus was satisfied the requirement for a school of mechanic arts, leaving an opportunity here for a separate agricultural college, — the only one of its class in the United States.

Governor Andrew's message to the Legislature in 1863 was a noble plea for the acceptance of the gift; but his plan was to unite the agricultural features of the gift with Bussey Institute, thus making the Agricultural College a department of Harvard University. The committee to whom the Governor's recommendations were referred discussed the whole subject with great ability, coming, I believe, to a unanimous conclusion that there was actual demand for a Massachusetts Agricultural College, and that it should be wholly disconnected with all existing institutions and separate from all large cities and towns; that it should recognize the principle of daily manual labor by its students as essential to success; and that the necessary funds for the founding of the institution should be contributed equally by the State and individuals. The Legislature adopted the conclusions of the committee; voted that the Congressional grant should be received, and the conditions faithfully complied with; and that the fund should be divided, in the proportion heretofore mentioned, between the college and the Institute of Technology. Later in the year the Board of College Trustees was incorporated, Mr. Wilder, of course, leading the list. The institution at the outset encountered considerable opposition, which was aggravated by the jealousy of rival towns who wished to secure its location within their own borders. The site and course of study were at first made subject to the action of the Legislature, but afterwards the decision of these important points was more wisely committed to the Board of Trustees. It was made a condition of the location that the municipality which received it should contribute $75,000 toward purchase of land and the erection of buildings. I remember very well, though I was not then a resident of the town, the great excitement which prevailed here over the question of securing the college. Seven cities are said to have contended for the honor of being considered Homer's birthplace; just about the same number of towns wrestled together for the Agricultural College. Springfield wanted it, so did Stockbridge, Northampton, Williamstown and Lexington, Harvard College and Jamaica Plain with its Bussey Institute, besides Amherst; and I presume there were other aspirants, — the returns are not complete. I do not believe there was a town in Massachusetts in 1863 that would not have jumped at the chance, if it could have found the way to put up the forfeit.

And now appears upon the scene that dashing and picturesque figure, Col. William S. Clark. He had left his professorship of chemistry at Amherst College at the opening of the civil war to go forth as major of the Twenty-first Massachusetts Regiment. He soon became its colonel, and gallantly led his command in some of the hardest fighting up to the end of 1862. It was under-

stood that he was booked for a brigadier-generalship, and this he would have had but for General Reno's untimely fall at South Mountain. In February, 1863, he was at home on a furlough, when the question of the acceptance of the provisions of the Morrill act was about to come up for action at the State House. I have always supposed that the resignation of his commission by Colonel Clark shortly after had some connection with his deep interest in the establishment of the new college. At any rate, he was out of the army in May, 1863, and from that moment was instant, in season and out of season, in securing the Agricultural College for Massachusetts, and afterwards for Amherst. Marshall P. Wilder, Dr. George B. Loring, the State Board of Agriculture as a body, and almost the entire citizenship of this town, were his able coadjutors. In the fall of 1863 he was elected representative from Amherst to the General Court, serving both in 1864 and 1865, and again, I believe, in 1867. It was a long and laborious task that he set himself, but in the end he won out at every point. He was made chairman of the House committee on agriculture the first year, and I assure you he magnified his office. Under his guidance, Governor Andrew's proposed Bussey Institute-Agricultural College combination was broken up; and it was no easy thing for any man or association of men to persuade the Legislature in 1863 to overrule any recommendation of our great-hearted war governor. The Massachusetts Institute of Technology made a claim for one-half the income of the Congressional fund, thus offering to satisfy the mechanic arts provision of the Morrill bill, and leaving the other half for the maintenance of an agricultural college pure and simple. There was a great struggle on this point, and the matter was finally compromised by giving the institute one-third the income, leaving the remaining two-thirds to the proposed agricultural college. Into the bill of acceptance was slipped the provision by some interested friend of the Connecticut valley — and we can safely guess who he was — that the new institution should be located in the interior part of the State.

The act of acceptance of the national benefaction on the conditions named, passed April 18, 1863, was unequivocal in its terms, and pledged the State to a faithful administration of the trust it assumed, and to watchful care for the wants of the college. It was hardly to the credit of a few opponents of this institution that they made a serious attempt, sixteen years later, to lead the old Commonwealth into a practical repudiation of its obligations toward the child of its own adoption, and to annul its solemn contract with the general government. This was an attempt which greatly alarmed the friends of the college. Happily it was triumphantly defeated, and the college became more firmly anchored than ever in the good-will of its constituents. In connection with this deliverance the college ought never to forget the inestimable service rendered the institution by that effective body, the State Board of Agriculture, led by its accomplished secretary, Mr. Flint.

Our act of incorporation bears date April 29, 1863. Mr. Wilder's name, of course, led the list of trustees, one-half of whom were members of the Board of Agriculture. The location of the college and course of study, originally vested in the Legislature, were afterwards very properly transferred to the

trustees, subject to ratification by the Governor and Council. Seventy-five thousand dollars was the amount of "graft" which the State claimed from the lucky town that might draw the prize of a college, which sum was intended to constitute a building fund for setting the new college in operation.

The fight for the location, and the raising of the requisite grant, were now on the carpet. The Legislature had just convened in January, 1864. Colonel Clark was there and everywhere. On the 25th of January a town meeting was held in Amherst, to see if the town would vote any sum of money to secure the location of the college here, and also to see if it would petition the Legislature to authorize it to create a bonded debt to raise the necessary funds. One hundred voters were present. Urgent speeches in favor of the measure were made by Colonel Clark; Edward Dickinson, treasurer of Amherst College, our most dignified citizen; Col. Ithamar F. Conkey, the brilliant advocate; and Luke Sweetzer, our leading merchant. Only the voice of Albion P. Howe, "mine host" of the Amherst House, was heard in remonstrance; and that only against the proposed bonded debt, for he needed the college more than any one else in town. The final vote stood 79 to 7 in favor of asking authority to bond the town in the sum of $50,000; but the Legislature of that year, after a terrific struggle in the House, declined to allow the town thus to burden itself. It was argued that this would be establishing a dangerous precedent, though there had been repeated similar enabling acts in aid of railroad schemes, notably in the case of the Troy & Boston or Hoosac Tunnel line. It was further urged in opposition that the movement was in utter disregard of the solemn rights of Amherst taxpayers, and would be an especially cruel sacrifice of the rights of women owning taxable property. And so Colonel Clark stirred up 446 taxpayers and voters — almost every male taxpayer in Amherst — to send in a monstrous petition to have their "rights invaded" for this object. In addition to this, Mrs. E. P. Hannum and 26 other widows of the town also prayed likewise, and Nancy Wait and 8 other maidens in a separate petition said "Amen." The introduction of the widows' petition in the House of Representatives provoked sarcastic reference to Sam Weller's estimate of that interesting class; and one facetious member proposed advertising a vendue, putting the college up at auction, and knocking it off to the highest bidder. Colonel Clark's advocacy of the measure on the floor of the House was brilliant in the extreme. His chief opponent, Erastus Hopkins of Northampton, was a man of extraordinary force and eloquence, always a resourceful and dangerous antagonist. The real opposition came from a union of rival towns in the strife over the location. Every one was determined to throw down all the others, and so the cause of Amherst and its proposed $50,000 bonded debt went down to temporary defeat. Such is log-rolling.

But the friends of the college in this vicinity were not discouraged, and they undertook the Herculean task of getting together the sum of $75,000 by voluntary subscriptions, for that was the amount required by the Legislature, to be raised by subscription or otherwise, for the purpose of erecting buildings. Exactly how this was done, no man can tell. Pledges of $50,000 seem to have been extorted from the taxpayers of Amherst, somewhat in proportion to their

taxable ability. How and where Colonel Clark obtained subscriptions for the remaining $25,000 is not clearly disclosed. Records at the State House, which have been gathered for me by that indefatigable worker, Mr. Fowler, librarian of the State Board of Agriculture, author of "The History of Early Agricultural Education in Massachusetts," to which work I am much indebted in this paper, show that $5,000 of it came from William Kellogg of this town and $10,000 from the benevolent manufacturer of Easthampton, Samuel Williston. If Mr. Durfee's gift of the plant house be counted as a subscription, that completes the requisite $25,000, leaving $50,000 to be subscribed for by the taxpayers of Amherst.

Now began one of the fiercest campaigns ever waged. On the 11th of April, 1864, the citizens of the town were called together at Agricultural Hall (not in a legal town meeting, however), to consult in reference to the location of the Agricultural College here. In the notice appears the significant announcement, "Colonel Clark is expected to be present." He was present. Committees were appointed to canvass all parts of the town, soliciting voluntary subscriptions. Meetings, or rather rallies, were held at the Center, the East Street, and at the "ends of the town." The community was financially raked, as with a fine-tooth comb. Men and women subscribed, and had to subscribe over again. Henry Cobb generously offered to double his subscription, and to pay $500 for others who could not afford it. At length the subscription of $50,000 was full, but I presume there was not a signer who expected ever to be called upon to pay; and so in fact it turned out, for not one of them ever was asked for the money. Poor Mr. Williston of Easthampton had to pay his $10,000, but his town got no college.

Other towns than Amherst had also subscribed like sums to secure the college, so that the trustees were now faced with the question of its particular location. They visited several places on this business, coming here in August, 1865, viewing this spot, and also the elevated ridge just below the town now called Mt. Doma,— the locality where the new observatory of Amherst College now stands, about a quarter of a mile to the southwest of President Harris's house. But right here was evidently the spot upon which Colonel Clark's heart was set, for he led the Board over these farms of Dick Cowls and Chester Cowls and those of their neighbors, shovelling and digging into the earth, and showing the remarkable variety of soils here available for study and use in experimental work. The conclusion of the trustees was reached early in the following month of September (1864), when by formal action they located the college on this spot, with its four or five farms, a total area which was finally brought up to some 375 acres. In November, 1864, the Governor and Council confirmed the action, and the Massachusetts Agricultural College *at Amherst* became an actuality. The opposition from Lexington, Springfield, Northampton and Berkshire County was carried even into the Council Chamber, where hearings were had, the mutterings of disappointment lasting months and even years longer.

But the great and final contest was yet to come. In 1865 Colonel Clark was returned to the House with practical unanimity, where he was to crown his efforts by one supreme accomplishment. Everybody recognized that to en-

force payment of the subscriptions in a town altogether destitute of rich men would be a public calamity. The subscribers had taken an awful risk; and now their cry of anguish was, "Bind us; bond us; give us an enabling act."

Governor Andrew's annual message of 1865 recounted the failure of his Bussey Institute plans, but generously promised his support to the college in its new location. He deemed it his duty, he said, to co-operate in giving vitality and efficient action to the plans of the trustees. He declared Amherst, of all places offered and possible, justly to be preferred, and commended the new college to the liberal care of the Legislature. He spoke of science as the inspiring leader of constantly advancing ideas, and made a noble plea for ideal excellence, foreseeing the time when "Husbandry, attended by all the ministers of science and art, would illuminate and rejuvenate the face of the world and re-create our life below." In commenting upon this address, the Agricultural Department at Washington said, in its monthly report for January, 1865: "Of all the official notices made by the executives of different States . . . in reference to the establishment of the land grant colleges, we admire and approve most that of Governor Andrew of Massachusetts, abounding, as it does, in sympathy for the industrial classes, and in a just perception of their real wants."

Early in the session the application of the town for authority to tax itself $50,000 as a donation to the Agricultural College came on for hearing. Mr. Hopkins of Northampton again appeared in remonstrance, accompanied by a prominent farmer of Amherst. His chief argument was the dangerous precedent. Colonel Clark met this by reading a resolve introduced into the previous Legislature by Mr. Hopkins himself, donating $100,000 to the sufferers of eastern Tennessee. He also showed that the Amherst farmer remonstrant had strenuously opposed the establishment of a high school some years before as an unnecessary and extravagant measure; and that, unlike the vast majority of his fellow citizens of Amherst, he was singularly devoid of public spirit. The colonel's powerful influence carried the bonding bill through the committee of the House and the House itself. The judiciary committee of the Senate, however, by a vote of 3 to 2, reported leave to withdraw. In open Senate the bill was promptly substituted for the adverse report, and was passed to be engrossed by a vote of 16 to 1; but the hard condition was imposed that an affirmative vote of two-thirds of all present and voting in a town meeting called for the purpose should be requisite to give validity to the bonds.

The greatest town meeting Amherst, perhaps, ever had, — certainly one of the greatest, the one that was to settle the future of the subscriptions, — came off at Agricultural Hall on the afternoon of May 8, 1865. The opposing cohorts turned out with full ranks. Edward Dickinson presented the votes, which had been drawn with unusual care, and made a brief statement calling for the yeas and nays on the first and decisive proposition. There was no debate. Every man's mind was too firmly made up to leave any room for argument. Could the two-thirds be secured? The vote was taken in solemn silence, broken only by the monotonous responses, "Yes" or "No." Under great tension the selectmen canvassed the vote and announced the result: 463 votes were cast, 359 in the affirmative, 104 in the negative. The cause was won.

The town had assumed the burden; the subscribers were safe. Nine mighty cheers greeted the announcement. The remaining necessary subsidiary votes were promptly carried. The meeting expressed its thanks to Colonel Clark for his successful efforts to procure the passage of the act, to which compliment the doughty colonel responded, as we are told, "in a neat and spicy speech, recounting some of the great obstacles encountered and overcome."

Judge Henry F. French of Cambridge, who had been prominent in advancing the interests of the college, was chosen its first president, in November, 1865. Not a building was then erected, and upon the question of their particular location on this tract much discussion ensued. One party was for Plant House Hill, which I am told was favored by President French, the architect, and by Mr. Olmsted, the distinguished landscape gardener. The decision finally fell on this spot, which was then called the "Flat," in distinction from the higher land to the eastward. The deliberate judgment of later years no doubt approves the final choice; but the differences then existing, and some other causes, led to Judge French's resignation in September, 1866, before he had rounded out a single year of service. The stately pine hedge, guarding the eastern boundary of the farm, was his legacy. President Chadbourne, who succeeded him three months later, remained only until June of 1867, when delicate health compelled his resignation. These were seven months of great industry and fruitful results. Much was done by him in outlining the general course of study adopted by the college, which was to a considerable extent an adaptation of the Hitchcock outline of 1851, and which many other of the State agricultural colleges, and some institutions abroad, afterwards closely followed. But at length Colonel Clark came into his own. He was elected president of the college on the first day of June, 1867, so that he was here to welcome the first entering class in September. But I have now reached the point to which I was asked by your president to go, in this rather rambling address.

In closing, may I be allowed to congratulate the alumni of the college, and you, Mr. President, as its official head, on the successes and triumphs of the first forty years of its literary and scientific life. For you and your associates, every one, I invoke the peculiar satisfaction and happiness which follow and reward the successful teacher. May these young men, and those hereafter to come as students in unbroken current, lay here deep foundations for lives of lofty aims, of unselfish service, and of ever-increasing influence and usefulness.

The Old Guard; The Famous "Faculty of Four;" The Mission and Future of the College; its Debt to Amherst College, Harvard College and other Institutions.[1]

Forty years ago to-day (Oct. 2, 1867), the Massachusetts Agricultural College opened its doors to the world. In commercial parlance it has paid one hundred cents on the dollar and more than one hundred fold on the invest-

[1] Read at the fortieth anniversary of the opening of the Massachusetts Agricultural College, Oct. 2, 1907, by William Henry Bowker of Boston, class of 1871.

ment. It has fulfilled the wildest hopes of its founders, and especially of its most enthusiastic champion, Marshall P. Wilder, then a far-seeing merchant of Boston, the son of a New Hampshire farmer.

It was as beautiful an October morning as this is to-day, when the "Old Guard" — the pioneer class of 1871, of which I was a member — met on this campus, then a farm field of orchard and mowing, subdivided with Virginia rail fences. Some of the Old Guard were dressed in home-made clothes, faded at that, and some in broadcloth and fine linen; for they came, as predicted by Judge French, our first president, from town and city, and from every station in life. This company of 50 or 60 green boys, as verdant as the farms from which many of them came, were huddled, like so many sheep, into small class rooms for the entrance examinations. Some had left home on the spur of the moment, without preparation for this ordeal, and had never before seen printed examination papers. They were formidable indeed. Here are two samples from the one in mathematics: —

Seven men laid a piece of wall 65 feet long in 12 days. Again, 11 men laid a wall of the same kind in 10 days. How long was it?

Another: —

A prisoner's cell is 7 feet long, 5 feet wide and $6\frac{1}{2}$ feet high. What would it cost to paint the whole inner surface, at $31\frac{1}{2}$ cents per square yard?

I am credibly informed that these problems are easy ones, but truth compels me to state that at least one member of the Old Guard was conditioned in mathematics.

I suppose there will never be any improvement in the method of admitting students to the higher institutions of learning; but I believe the one employed at the opening of this college is the best I know of, for it evidently was based on the looks or "hang" of the boy, rather than on his attainments. It certainly fitted the case of some of us, and therefore I am bound to commend it to other institutions. It is my recollection that every boy was admitted, — some with conditions, it is true; but I do not recall that any of us were ever required, or even expected, to make up the conditions.

The authorities of forty years ago, the famous "Faculty of Four," were wise, far-seeing men. They realized that a college could not start without students, and knew the advantage of a large entering class; therefore they probably decided to make the best of the situation, to take us all in for better or for worse, and to do the necessary weeding out later on. That they did not do much severe weeding is evidenced by the fact that the Old Guard, which entered with 56 members, graduated with 27, — a larger proportion of the entering class than has since prevailed in this college, or than usually prevails in other institutions.

The Location of the College, and President French.

I suppose the location of the college in this town, forty-three years ago, is largely due to the efforts of Col. William S. Clark, then professor of chemistry in Amherst College, and to Levi Stockbridge, a young farmer in Hadley. It was they, assisted by others in the State, who defeated in the Legislature the plan to combine the college with Bussey Institute, which was then, and is now, the school of agriculture connected with Harvard College. By almost a unanimous vote the Legislature determined that it should be started as an independent institution; that it should stand or fall on its record and by itself, — a wise decision, as time has proved, for it was regarded as a joke in some quarters, and frequently laughed at. Its location, however, was no mean contest, as the town of Amherst was not only in competition with the most powerful college in the State, but with such towns as Springfield, Chicopee, Northampton, Lexington and many others. It was located at Amherst, on May 25, 1864, by a vote of the trustees, which stood 10 to 4, afterwards made unanimous; but a compromise had been previously effected, by which one-third of the income from the funds derived from the sale of the government lands was given to the Institute of Technology for instruction in the mechanic arts, and from which this college was thereby relieved. I am inclined to think that the location of the college in this town, in view of what the town and the old college offered and had done in the cause of agricultural education, was a wise move, on the whole, and that the division of the funds and of the work to be done was an advantage to both the college and the Institute of Technology.

The college was, perhaps, unfortunate in having three presidents in the first three years of its incorporated existence, and before it opened its doors. Its first president, Henry F. French, was the son of a New Hampshire farmer, a graduate of Dartmouth College and a lawyer by profession, having served on the bench. I did not know Judge French well, but I am informed that he was a keen, sensitive man, with a good mind, highly trained and well informed, rather distant in his manner, but of a kindly nature. He was a clear thinker, a terse writer and an authority on several agricultural subjects, — a man who was much in advance of his time in farm precept and practice. If he was a patrician in his looks and manner, he was certainly democratic in his sympathies and in his proposed plan of organization and development of this college; therefore, why he was allowed to resign the presidency at the end of his first year I am at a loss to understand. It was given out that he resigned because of a disagreement in the Board of Trustees as to the location of the buildings, he standing for the Olmsted plan, which, according to tradition, placed the buildings on the Stockbridge Road, where Wilder Hall and Clark Hall are now located. Personally, I think he was right; but it seems, at this distance, a small matter to quarrel over, and, if it were the real reason, too trivial to cause his resignation. I think it was the impression at the time, and recently confirmed by his son, Daniel Chester French, that the Board and his father were in disagreement as to the policy of the college; but the nature of that

disagreement I have not been able to ascertain. Judging, however, by his first report, he must have stood for an institution of broad scope, as provided in the deed of gift from the general government. I consider this report, or essay, on education, a classic in agricultural literature, and deserving of re-publication. Here are some gems taken from it: —

Our college is to be established as a part of the great scheme of public education; not in opposition to our grammar schools and high schools, but in harmony with them; not as a rival to our other excellent colleges, but as a co-worker with them in a common cause.

Discussing agricultural education in England, he says: —

An agricultural college based upon republican institutions, and adapted to them, will differ essentially from any college existing in a country controlled by an aristocracy. Aristocratic governments are constructed upon the idea of inequality in property, in education, and, *therefore*, in political rights and power. We use the word "*therefore*," because wealth and education, monopolized by any class in any country, will draw to that class the political control of that country. . . . The comfortable farmer of England, on his thousand acres of leased land, is as unconcerned about public affairs as one of his own fat bullocks. He trusts his spiritual affairs to the church, and his political affairs to his landlord, and cares not what party rules, provided the markets are good. . . . Republicanism has undertaken in America to recast society into a system of equality. . . . Its purpose is to diffuse education and *property* among all the people; to give as nearly as possible every child an even start in the world. . . . Therefore, in deciding on a course of study and discipline for an agricultural college, we must ever remember that we live under a republican and not an aristocratic government.

Answering the question that the college may educate away from the farm, he says: —

We apprehend that no parent desires so to educate his son as to cheat him into a false belief on this point. No! give him education in the truth, and when he is graduated, let his stand-point be elevated enough to overlook the whole country. . . . Let him go where duty and interest call him, well qualified for whatever he may undertake; and his father's blessing will not be withheld.

He closes with this splendid thought, which is particularly apt at this time, when we are met to consider rural progress and betterment: —

A rural life, well lived, is no doubt the happiest of all, and the most healthful for soul and body. The words of the poet are golden truth,

"Happy the man who hath escaped the town,
Him did an angel bless, when he was born,"

and let it be a part of our mission so to teach.

Forty years ago it took a man of courage and convictions and of broad vision, trained in the old school for the law, to leave his profession and the classic shades of Cambridge, where he then resided, to become the head of an institution that proposed to make agriculture its leading subject; to drop out Greek and Latin, and substitute therefor the sciences and arts related to agri-

culture; and to include, also, manual training in its curriculum,— a distinct and radical departure at that time. It is no secret that it was a great disappointment to him to give up this work because of radical differences between himself and his Board of Trustees; but I believe history will accord Henry F. French a larger place in the annals of this college and in the cause of agricultural education than he has held heretofore.

Judge French was followed by Prof. Paul A. Chadbourne of Williams College, a graduate of that institution. He was a forceful yet charming scholarly man, who took a broad view of the work and future of this college. Unfortunately, at the end of his first year he was forced to resign because of illness, being attacked by hemorrhage of the lungs. Although with us but a few months at this period (later he was again made president), he left an enduring mark, chiefly in clearly outlining, as he did in his first report to the Legislature, the scope and policy of the college, charting, as it were, a course almost identical with French's, which we have pretty closely followed to the present time.

THE FAMOUS "FACULTY OF FOUR."

The first catalogue of the college records 56 students in the opening year, a Board of Trustees of 17 members, a Board of Overseers of 36 members, and a faculty of 4 members. That original and famous "Faculty of Four" consisted of William S. Clark, president and professor of botany and horticulture, and director of the botanical gardens (then existing only on paper); Levi Stockbridge, farm superintendent and instructor in agriculture; Ebenezer S. Snell, professor of mathematics; and Henry H. Goodell, professor of modern languages and instructor in gymnastics and military tactics. These four men, then in the prime of life, were the first teachers and leaders of the Old Guard. They were a well-balanced and inspiring team, equal to every emergency,— and there were many of them in the early days.

The third president of the college, Col. William S. Clark of Amherst, was a product of western Massachusetts and its institutions; a man forty-two years of age, of fine presence, of splendid mental and physical vigor; a lover of good horses, who always drove a spanking team; a man who had served with distinction in the civil war; a forceful speaker and writer; a splendid organizer; and a brilliant teacher, who inspired youth to better things. In modern slang he would be called a "hustler," for he had a way of getting there a little sooner than anybody else. To illustrate: when our college won the first race in 1871, at Springfield, in the National College Rowing Association, defeating Harvard and Brown,— the pioneer class contributing, by the way, half the winning crew,— Clark came tearing into Amherst behind a team of high-steppers, hat off, crying, at the top of his voice, "We've won! We've won!" That race of Clark's against time, from Springfield to Amherst, was characteristic of the man.

Although not a profound scholar, he was splendidly equipped to become the president of this institution. He was not only a graduate of Amherst College, and had taken his doctor's degree in chemistry at the University of Göttingen, Germany, but at the time of his election he was professor of chemistry and botany in the old college, and had devoted much thought to the study of

these subjects as applied to agriculture. This splendid preparation, together with his service on the Board of Agriculture and his vigorous work to secure the location of the college in Amherst, made him the natural successor of French and Chadbourne; and undoubtedly, at that juncture, a better-fitted man than either to inaugurate the beginning of a new departure in education in the State and in the nation, our institution then being the third agricultural college founded in the country.

Clark, in his first report to the Legislature, in 1868, writes as follows: —

> Encouraged by the successful opening and prosperous condition of the institution, the trustees confidently hope that the college which Massachusetts has honored with her name and pledged herself to maintain forever, and which is peculiarly the people's college, will receive from your honorable body the means necessary to carry out, in a credible manner, the plan adopted for its organization.

How many times afterwards were Colonel Clark and Professor Stockbridge compelled to plead with the Legislature, and even forced to use their private funds and endorse to the local banks the paper of the college, to keep it going! But Clark was a man of imagination, who saw the need of this institution, and who had unbounded confidence in the ultimate good faith of the State toward it; and so he worked on.

Clark Hall, now completed and to be dedicated to-morrow to botanical training and research, is a fitting monument to the first aggressive and inspiring president of the Massachusetts Agricultural College, who left in this State, as in Japan, where he founded the first agricultural college of that country, an enduring record in the cause of education.

The next man in that famous "Faculty of Four" was Levi Stockbridge, first appointed farm superintendent and superintendent of new buildings. Later he became instructor in agriculture, from which he rose to be professor of agriculture, and finally president of the college. His great work is written all through the annals of this institution, long before it was incorporated and located, — on the Board of Agriculture, in the Legislature, on the platform, and eventually as a member of the faculty and president of the college.

While Clark was the aggressive leader and undoubtedly the hero of the boys of my time, Stockbridge was the shrewd, level-headed man of the faculty, the balance-wheel, the "father confessor," the "ever-present help in time of need." He, like Clark, had unbounded faith in the future of the college and in the good faith of the State towards it.

Stockbridge was thirty-seven years of age when he came to this institution, — a tall, thin, wiry, untiring farmer, who could work all day without food, if necessary, and still keep fresh for the day's work before him. He was a contribution from the public schools, — a self-educated man, so called, which I believe is now considered a misnomer. In that remarkable faculty he was no doubt the peer, if not the superior, in native wit and capacity. As he stood for agricultural education not alone in the college but throughout the State, a fitting monument to him would be a building to be known as Stockbridge Hall or the agricultural building, the keystone of all the buildings now erected or hereafter to be erected on this campus.

The third important man in that first faculty is our late, lovable Goodell,— a boy with us in '67; the general utility man of the faculty, teaching all the languages (modern, and ancient if necessary), besides gymnastics and military tactics; also a monitor in the early days,— the appointed guardian of our moral and physical welfare. He was an excellent disciplinarian, a splendid teacher, and a man looking for the good in everybody, which he invariably found and brought out. Great in his goodness of character and life, and of charming personality, he left a lasting impress on the annals of this institution.

As president of the college, in which capacity he served for nineteen years (the longest period of service up to the present time), he did notable work. When he took the helm the college was still not sure of its course; but when death called him from his duties he had steered the institution into safe waters.

His greatest work in the cause of education was done at Washington, where, as chairman of the national committee representing the land-grant colleges and experiment stations, he spent much time seeking and finally obtaining from Congress the recognition and financial support which these rapidly growing institutions required to keep pace with the demands made upon them. His frank, open, sincere manner, coupled with a cheerful nature, although at times he was a great physical sufferer, enabled him to succeed where others had failed. The son of a missionary, born in Turkey and educated in a classical institution, he devoted practically his whole life to the cause of industrial and vocational education. As a lover of good literature he inspired a similar love in many of his students; and his greatest monument in the college is the library, which is considered one of the richest in agricultural literature, and which some day should be housed in a suitable building, to be called the Goodell Library.

In speaking of the "Faculty of Four" we must not pass by that dear little, dried-up, sparkling professor of mathematics, loaned us from Amherst College,— Ebenezer Snell. He was with us but a year, but he taught mathematics so thoroughly and in such an interesting way that he influenced some of the brilliant men of the class to take up higher mathematics, and eventually to become distinguished engineers. He was as sweet in his life and example as he was great in his profession; but he had no use for a numskull in mathematics, so some of us never got very close to him. I recall that one day the present clerk of the city court of Springfield was called upon to demonstrate a problem in geometry, step by step, and he "flunked," as usual,— as did some others. Snell said to him, "If you were going up a ladder, and some of the rounds were missing, how would you get up?" and the young man retorted, "I'd shin up." "That would be possible in the case of a ladder," said the smiling professor, "but you will find that you cannot 'shin up' mathematics."

The "Big Four" and the Growth in Forty Years.

In the fall of 1869, the faculty, as printed in the catalogue, had increased from 4 to 12. Of the 12, only 5 were resident members, one of whom was Charles Anthony Goessmann, who has recently celebrated his eightieth birthday and his thirty-ninth year of service in the college,— the last link between

the old and the new, the last living member of that "Big Four," Clark, Stockbridge, Goodell and Goessmann, who, each in his own way, contributed so ably and loyally to the upbuilding of this institution.

Goessmann was a contribution from the University of Göttingen, Germany, and was no doubt the best-trained man in the faculty of that day. He has left his stamp, both as a teacher and as a student of the problems of nature. He was familiarly known to us as "Dutchy," but in our true estimate of him he was Goessmann the chemist, the investigator, the philosopher, the courteous and cultivated gentleman, whom we loved and still love for the good he has done. May he live to see erected on this campus a suitable building for the chemical department, which shall be known as Goessmann Hall.

In 1871 (the year we graduated) the faculty had increased from 4 members in '67 to 28. Of these 28, only 10 were resident members. The remainder were composed of well-known lecturers, and included such distinguished men as Charles L. Flint, James Law, Edward Hitchcock, L. Clark Seelye, and, last but not least in rural law, Marquis Fayette Dickinson, a graduate of Amherst College, and now an honored trustee of this college. To-day the faculty consists of 30 resident members, besides a large staff of trained investigators connected with the experiment station, — an important department, which was established some fifteen years later than the college. As I stated, 56 students were enrolled in 1867. In this calendar year of 1907 there will be enrolled, including the summer school and short course pupils, over 500 students. Thus have we grown in equipment and attendance in forty years.

The Old Guard and what they did for the College.

In 1871 the Old Guard had completed their four years' course and received their diplomas. While the faculty professed to love us (and I think they did) as a parent loves his eldest son, yet I think they were glad to see the last of us; for, being the pioneer class, the experimental class, we had taken advantage of our position, and had no doubt given them many bad moments and some misgivings for their splendid efforts in our behalf, which at times they must have thought were squandered on a heartless group of youngsters.

I recall that when a non-resident member of the faculty, a Trinitarian minister, was delivering his Sunday sermon, some remark in it caused a smile to pass over the faces of some of the members of the class. The minister stopped in his discourse, and, looking over his glasses, remarked: "Young men, I see the smile of scorn curling on your lips; but let me tell you that if you do not accept and practice the doctrines which I have proclaimed, you will be eternally damned."

It is true that some of us read the writings of Charles Bradlaugh and Robert Ingersoll; that some would walk miles to hear Wendell Phillips and Henry Ward Beecher, and would sit up nights to read George Eliot; that some admired Horace Greeley, and voted for him in '72; that some were rank free-traders, and enjoyed Professor Stockbridge's denunciation of a plutocracy and believed in his plan of limiting fortunes; yet, on the whole, I do not think that we were a bad lot of boys. Like most college students, we were simply

bubbling over with animal spirits and with some peculiar notions which we had imbibed from the liberals and radicals of that day,— notions which were soon to be modified, if not rudely dispelled, as we took our cue in the great drama of life.

The Old Guard of '71, led by the "Big Four,"— Clark, Stockbridge, Goodell and Goessmann,— did a greater work for this institution than the public is aware of. In the first place, we paid our way; that is, we not only paid tuition (which is now free), but, under the guise of manual training, which was then considered necessary in our education (and I think it was), we dug ditches, as instruction in drainage; we cut down and uprooted apple trees, as lessons in forestry; we leveled Virginia fences and graded land, for landscape effect and education; we milked cows and groomed horses, which I suppose would come under the head of veterinary science and practice; we mowed grass and harvested corn, which undoubtedly must be classed among the arts of agriculture; and for all of this compulsory labor (and there were six hours of it each week for each boy) we never received a penny, as it was considered instructive manual training.

We have here a beautiful campus. Let me tell you, friends, that the Old Guard, led by the "Big Four," laid the foundations for what you see to-day. They were the Irish and Italian laborers of their time, building better than they knew. Among other things, the Old Guard planted around the center of the campus a row of elm trees which are standing to-day, one for each graduate,— splendid specimens of their kind, and I hope truly representative of the pioneer class. Of the 27 who graduated thirty-six years ago, 24 are known to be living and in good health. Perhaps their longevity is partly due to the manual labor, military drill and dumb-bell practice which they were compelled to perform during their college course.

The Strike against Manual Labor in the College.

Probably, the first and perhaps the last, labor strike in an educational institution occurred on this very spot. For three years the Old Guard had toiled and worked at manual labor,—digging ditches, felling trees, etc., felicitously called "educational" in the catalogue; but in the spring of 1870 we concluded that we had done about enough of this sort of work, and asked that we be excused from it, and in future, if any manual training were required, it should be more instructive and less manual. Had not Judge French said in his first report that "The manual labor required under the charter should be for the education of the student, and not for profit, and therefore should be graduated accordingly?"

The obdurate faculty would not listen to us. We sent a petition to the trustees, which probably never reached them, for the "Big Four" were a law unto themselves. The result was that we struck, and packed our trunks. Then negotiations began. A meeting of the class was called at the chapel, and presided over by our class president. President Clark was invited to attend. He came,— which was a very great mistake on his part, as he soon discovered. We presented our case, and Clark replied in no unmeasured terms,

declaring that we were in rebellion against the college. Then it was that our honored Wheeler, now a member of the Board of Trustees, — who, by the way, had been excused from manual labor in order to assist in teaching the lower classes in mathematics, — rose to the occasion and punctured the claim that we were in rebellion by putting this leading question: "Mr. President, do you consider it rebellion to demand the fulfillment of the contract plainly set forth in the catalogue, that the manual labor required would be in the nature of manual progressive training?"

This brought President Clark to his feet with the remark, made in considerable heat, that he "had not come there to be lectured to;" and drawing from his pocket that famous document of recantation and promise of immediate obedience to college authority, under the penalty of expulsion, and producing the wherewithals for its immediate signature, to wit, a pocket inkstand and pen, he marched out of the room, with that air of command of which he was so capable, and which we are agreed generally so well and worthily became him. It is my recollection that not a single man signed the famous document of recantation, but that we all stood firmer still for our rights.

We struck, as laborers usually strike, at a crucial moment. It was the spring preceding the year we were to graduate, — and what would a college do without a graduating class? Days elapsed, and letters came pouring in from our parents at home, directing us to desist; but we displayed no flag of truce. Finally, through the diplomatic and friendly offices of "Prof. Stock," "Dutchy" and "Farmer Dillon," the obnoxious document of recantation was withdrawn, and assurances were given that manual labor would be limited to progressive and educational lines if we would return to the next labor exercise. We agreed to this compromise, and soon after the announcement was made that class work for the senior year would be abolished.

A Lesson from this Strike and the Duties of the Faculty.

I have dwelt at some length on this episode in our college life in order to draw a lesson from it. After a period of thirty-six years I look back with no regret for my part in that strike, still feeling that we were in the right. My experience since then in dealing with men, and as a member of the Board of Trustees, has shown me that we can count upon any given group of young men, if they are not vicious, as likely to be fair and just in their conclusions; and I want to say to the trustees, and especially to the faculty of this college, that in my opinion the benefit of the doubt should always be given to erring boys, to the end that they may be saved *chiefly* from themselves.

If the pioneer class had been expelled because of the labor trouble, it would have ruined the future of many of that class and would have been a great blow to the college. While rules and regulations are necessary, and while education is primarily mental and moral discipline, yet these are but dry husks if they are not mixed with the "milk of human kindness," with generosity, with consideration, and with a careful study and appreciation of the characteristics and tastes of each individual composing the student body. Some day we shall study the boy and his capacities and tastes as much as the

things we teach him; and some day we shall bend our efforts to discover what he is best fitted for, in order to develop him for his proper field of labor. By this method we may not turn out as many well-rounded gentlemen as the old school of training developed, but I believe we shall send out men better fitted to take up and carry on the world's work.

Let me say especially to the president and faculty of this college, as I have the right to say, after forty years' connection with it, that in my opinion your duties do not begin and end with the lectures which you prepare and deliver. Your duties, and particularly your responsibilities, begin with the boy who comes to you as much for guidance and sympathy as for instruction, and they do not end until he has received his degree at your hands. To study, direct and encourage the individual of the student body, as well as to instruct him, should be the end and aim of every teacher, whether he is employed in the graded or preparatory schools or in the higher institutions of learning. I am glad to state that within a month a committee of the trustees has instructed the dean of the faculty, Professor Mills, to visit Princeton College for the purpose of studying the tutorial system which President Wilson is trying to introduce in that institution. We wish him success, for we believe a reform is needed in the manner of reaching and molding the individual student,— needed as much here as at Princeton.

The Land-grant Colleges and their Mission.

As you all know, the Massachusetts Agricultural College is one of the thirty land-grant colleges established under the Morrill act of 1862. These land-grant colleges, particularly in the Western States, have grown to be great democratic universities, and are so vigorous and original in their methods and in their work that they are giving the eastern institutions of learning some valuable lessons, and, I fear, some unhappy moments. Without traditions, and without the conventions which traditions always impose, these agricultural colleges and State universities of the west are demonstrating that education can be made both vocational and cultural, and that while the study of the classics is desirable, it is not necessary to turn out a well-rounded man. The battle is on between the old and the new school of education, with the prospect that the old school will gradually move into the field and adopt the methods of the new. As an index of this movement, witness the development in the past few years of the technical and vocational courses in connection with the classical colleges and schools of the east.

Our humble institution, being placed in a small State and competing with a dozen colleges and technical schools, one of them the oldest and richest in the land, was compelled to "blaze" a path for itself. It was a wise policy which determined that it should be an independent agricultural college from the start,— not in the narrow sense of teaching agriculture alone, but in the broader sense of teaching all the natural and applied sciences which are related to agriculture, and at the same time, while training men along vocational lines, of giving them as liberal an education as possible, in order to fit them to be good citizens and to do their part in society. In other words, the

trustees have sought from the start to fulfill the requirements of the deed of gift from the general government, namely: —

To maintain at least one college where the leading object shall be, without excluding scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

Our first two presidents, French and Chadbourne, clearly saw the scope and future of the institution, and marked out the course which it should pursue. Chadbourne, in his report to the Legislature in 1867, clearly set the pace, as follows: —

The fear is expressed by some that, if an attempt is made to give a truly liberal education, the students will turn aside from agricultural to other pursuits. Undoubtedly some of them will. If such an education is given in practical science, as ought to be given in such an institution, there will be a demand for its students as teachers and in other professions. And it would be an education entirely unworthy of Massachusetts, and contrary to the plain intent of the act of Congress donating the land, if it were so meagre in its requirements that the students should be fitted only for one pursuit in life. No surer way could be devised to defeat the very end for which the college was established than to conduct it on a plan which proclaimed, in theory and practice, that its students were to be kept in ignorance of certain things, lest they should be above their calling. No institution can ever succeed on such a plan, *and it ought not*. It is difficult to see what a student would enter such an institution for.

The Whole State is our Class Room.

Judge French said, in '66 : —

The objects of institutions of learning are twofold, — the diffusion and the advancement of knowledge.

adding : —

When our classes are filled and our organization completed, let our motto still be *progress*. Let us pursue our study beyond the mere instruction of classes in their prescribed courses, and endeavor, by careful experiment in the field and careful investigation in the study and the laboratory, to make discoveries in science and to enlarge the boundaries of existing knowledge, fixing no limits to our researches but the limits of finite intelligence.

Thus, in addition to educating resident students, who have been few in numbers until recent years, we have done a yet greater work. For years before the establishment of the experiment station we were carrying on instructive experiments for the benefit of the farmers, and our faculty were lecturing at farmers' institutes throughout the Commonwealth. In 1882, through wise legislation of the State, the third experiment station founded in this country was established on these college grounds, and it has taken up and carried on the work where the college faculty left it. This station, now a department of

the college, is reaching out to every farm and farmer in the State to-day, as in the past; so we are not only training resident students in our class rooms, but the whole State is our class room, into which everybody is invited to come, whatever his calling or station in life, and we will help him if we can, and especially if he has troubles which come in our line; and who does not have such troubles, whether he owns a shade tree or a forest, a garden patch or a thousand acres?

It must be remembered that we are the State college,— the "people's college," as President Clark said in his first report,— not founded for any particular class, but for all classes in the Commonwealth. In 1867 the pioneer class contained representatives from all walks in life,— sons of lawyers, doctors, farmers and others; and such has been the case in each succeeding class to the present day. Likewise, the college has turned out men trained for almost every station in life, as both French and Chadbourne said it should do, to be worthy of the State.

Has the College fulfilled its Mission?

We know that the time has gone by when a boy is sent to school or college to be kept in ignorance of certain things, in order to be better prepared and retained for a special calling in life. We know that the young student is not now sent to Amherst College to be trained for the Trinitarian ministry, or to Harvard College to be trained in the Unitarian faith, but to be broadly prepared for any pursuit in life. So students have not been sent to this institution for education in agriculture alone, because that happens to be its title; nor have we kept them ignorant of other things, for fear they might stray to other pastures. Such a plan, if allowable, presupposes that the son must follow in the footsteps of his father; that a man born of a carpenter must follow his father's trade, whether suited to it or not. Jesus was the son of a carpenter, but he left his father's workshop to become the great Teacher of the human race. Boys will be sent here, or should be sent here, not to be molded or warped into something for which they are not fitted, but to be made the most of; and if we have turned out, in the past, great engineers, leading journalists, or men fitted to be judges in our highest courts, as has been the case, it is to our credit, for it shows the breadth and excellence of our training.

Let it be understood that we hold in this institution that the study of agriculture, with all the sciences and arts which are related to it,— and what sciences and arts are not related to it?— can be made a cultural as well as a vocational means of education; that, while it is well to know Greek and Latin and the great classics of literature, these are not absolutely essential to develop a useful and cultivated citizen. Let it also be known that, while we have educated professional and business men, and shall continue to do so, the great majority of our graduates have taken up some form of agricultural work or some pursuit allied thereto. Thus have we fulfilled the mission of the institution, namely, "To promote the practical and liberal education in the several pursuits and professions of life;" but at the same time we have kept at the front and thoroughly taught "such branches of learning as are related to agriculture."

Why have we not sent out more Graduates?

But we are often asked why we have not sent out more "Aggie" graduates. There are many reasons. Forty years ago, if it took courage to become the president of this institution, as it did, it certainly took courage on the part of the young student to come and remain here, when the tendency of the times, and in many cases the home influence, was against it, and in favor of classical education. I remember an older brother of mine saying to my father, "What does Bill want to go to the Agricultural College for, unless he intends to be a farmer?" And at that time who would start out as a farmer in the east, perhaps on borrowed capital, in competition with the west and its cheap lands, and when other occupations seemed to offer pleasanter and richer fields?

Some day this college will be a popular institution with all classes; but, it must be remembered that it has never been a fashionable institution, and I hope it never will be, for when fashion touches a school or a college — or a church, for that matter — it usually ceases to be democratic and becomes exclusive and moribund; then its hour has struck, and the janitor can put up the shutters, lock the door and go home. It must also be remembered that this college has never had as feeders a certain great group of exclusive and inbred preparatory schools where a boy is enrolled at his birth.

Further, the teachers of the high schools in our State have not been in full sympathy with us, for most of them are graduates of the old colleges, steeped in the old-school notions, and naturally they have influenced boys to go to their favorite institutions. Neither has the press been wholly in sympathy with us, because its editors are largely college-bred men of the old type, and to this day some of the papers persist in printing our name in lower case; even the agricultural press at times has been lukewarm. And as for the farmers, for whom the college was supposed to be established, they have contributed until recently less than half the students. But what could we expect, when the farmer himself, and his wife and daughter, discouraged at the outlook, have not wanted the son and brother to follow in the footsteps of the father?

In the face of such conditions, is it any wonder that our growth has been slow, even if it has been healthy and sure? We must not congratulate ourselves, however, that this healthy condition is due to our good management, for, being human, we have erred at times. The growth and success which we see to-day are largely due to the fact that there was a need for this institution, especially in the field of experimentation; that there was a demand for the kind of training it offered. Its courses of study and its practical work in the field appealed to the common-sense of a large number in all stations in life. Thus it is not strange that our students have come from the city and the town, as well as from the farm.

If it had been thoroughly understood that the education offered at this college is broader than its name, or rather that its name is broad enough to include nearly all branches of knowledge; that a graduate need not necessarily be a farmer, but is well fitted for other pursuits, — many a discouraged farmer and his family might have cast their influence for us, and thus we might have drawn a larger proportion of our students from the farm than has

been the case. Now, however, that agriculture in all its subdivisions is looking up; that the public are realizing that a scientific farmer can be a practical farmer and a cultivated man as well; that he is to be, as he was in the early history of this nation, a controlling factor in shaping its course,— the farmers and others in the State are sending their sons here in greater numbers; and before the next forty years come around, I predict that this institution will be crowded with young men desiring to study agriculture for the sake of agriculture, as well as all those branches which help to make useful and patriotic citizens.

No doubt the social status of an educational institution has a great influence upon its attendance and the student body. Here at Amherst, in the State college, it will have no influence whatever. The test will be, What are we doing for the nation which founded us and the State which supports us? In fact, this should be the test of every educational institution, for no one of them, whether public or private, can be independent of the State. Following the lead of some other countries, notably Switzerland and France, why should not the State, through its Board of Education, have oversight of all its schools and colleges, that it may know what its youth are being taught? In this, our only State college, the Governor appoints the Board of Trustees, and the secretary of the Board of Education is a member by virtue of his office; and under its charter the course of study is subject to the approval of the Governor and Council.

The Future of this College and its Debt to Amherst College.

I am reminded by the circular announcing this meeting, that, while the historic and anniversary aspects will not be disregarded, "the outlook is towards the future." It is never safe to prophesy; but with the establishment of the normal department, which is to be opened this fall, for training teachers that they may introduce nature studies in the common schools of the State, particularly in the rural districts, and with the introduction of agricultural high schools, one of which has already been opened in Petersham, we anticipate that much of the academic work which we now have to do will be eliminated, and that at no distant day we shall deal chiefly with the larger and higher educational problems; that men will do their academic work before they reach us, and will come here for advanced training in the natural and applied sciences. Who knows but that one day we shall be a college for advanced or post-graduate work in all departments of education, and that Amherst College, on yonder hill, will be a preparatory school for us!

But let me hasten to say that the Massachusetts Agricultural College, and agricultural education in this State and in the nation, owe more to Amherst College than the public realizes. An examination of the records shows that in 1850 Dr. Hitchcock, then president of Amherst College, and Marshall P. Wilder, then president of the State Senate, were commissioned to visit and study the agricultural institutions of Europe. Dr. Hitchcock wrote the report; and some of the recommendations, particularly in relation to agricultural schools, are as sound and useful to-day as they were when published, fifty-

seven years ago. The first practical outcome of this investigation, chiefly carried on by Dr. Hitchcock, was the establishment of the Board of Agriculture,— the first to be founded in America,— which prepared the way for the agricultural college that was incorporated fourteen years later.

As President Hitchcock's report was published broadcast, it is more than likely that Senator Morrill of Vermont read that report, and perhaps gained from it the inspiration which led him to introduce into Congress in 1857 a bill requesting that "public lands be donated to each State which provides colleges for the benefit of agriculture and the mechanic arts." Consideration of this bill was postponed because of the civil war, but it was finally enacted in 1862; and to it we owe the great, democratic land-grant colleges of this country, such as Cornell University and the universities of Iowa, Michigan, Illinois and Wisconsin,— in fact, we have one in every northern State.

As far back as 1843 we find Prof. Charles W. Shepard listed among the faculty of Amherst College as lecturer on agricultural chemistry and mineralogy; and in 1852 the college offered a course in agriculture, independent of the regular college courses. Again, in 1853 President Hitchcock proposed to the Board of Agriculture that farmers' institutes, like teachers' institutes, be held throughout the State,— a suggestion which was not carried out until many years later, but which has now been adopted throughout the country.

Amherst College was of very great assistance to this institution in its early days. She not only gave us the use of her splendid laboratories, museums and library, but in my time she loaned us many of her able faculty as lecturers and teachers. Thus did the old college help the new college, as well as the cause of agricultural education throughout the country. Therefore it is but fitting that this debt to Amherst College and its great president, Edward Hitchcock, pioneers in agricultural education, should be acknowledged at the fortieth anniversary of the opening of the Massachusetts Agricultural College.

The "Bucolics" and the "Intellectuals."

Forty years ago the Amherst students called us the "bucolics," and we retaliated by calling them the "intellectuals." I do not know what epithets there may be to-day between the students of the two colleges, but I am sure that the colleges are not jealous of each other; that if they ever had any differences they have buried them; that the faculties of each are meeting and associating on common ground; that the students are in friendly rivalry in athletics,— to use a bucolic simile, that the two colleges have met in the great common pasture of human knowledge; that they are browsing and ruminating together, chewing the "cud of wisdom" in the encouraging sunlight of the present day, drinking at the refreshing springs of truth for the nourishment of the human race.

Looking, then, far into the future, who knows but that some day, in the economy of effort and for the common good, these two colleges, the old and the new, will be united into a great university, under some appropriate name, as the Massachusetts Agricultural University, with a college for academic training, a college for agriculture and applied sciences, and such other colleges as a

well-ordered and modern university should contain, — a broad, progressive university, which shall be to this Connecticut valley, this great and growing center of education, what Göttingen University is to Germany, and what modernized Oxford (the first college to teach agriculture) will be to Great Britain?

Our Debt to Harvard College and Other Institutions.

I ought not to close this address without acknowledging our debt to other colleges for the presidents and teachers they have sent us and for sympathy and co-operation in various ways. It should be remembered that Harvard gave us our fourth president, Charles L. Flint, a man of fine mind and superior scholarship, who was the first, and for twenty-seven years the distinguished, secretary of the Board of Agriculture. She has also contributed many influential trustees, who have given time and money to this institution. But I think the finest thing that Harvard men did for "Aggie" men was in insisting that our degree of Bachelor of Science should be recognized in the University Club of Boston, — and let me say it was recognized largely through the efforts of Samuel Hoar, then a "Fellow of Harvard College," who rarely knew defeat. For this kindly act, as just as it was generous, we were very grateful; although a small matter, it was significant of the change in feeling of college men towards the State college. As indicating the feeling of college men to-day, I wonder if the degrees of the other land-grant colleges and State universities are now accepted in all the university clubs throughout the country?

We must remember that, while Amherst College gave us our two leading presidents, Clark and Goodell, yet that Dartmouth, Williams and Brown each contributed a president, — in fact, that nearly all the well-known sources of scholarship and scientific training have contributed to the upbuilding of this institution; and we are proud to say that we are now able to reciprocate, to return in kind, and that we are sending our sons to be presidents and professors in other institutions.

President Butterfield and his Mission.

It has remained, however, for the Michigan Agricultural College, a sister institution, which has recently celebrated her fiftieth anniversary, to train for us our ninth and last president, Kenyon L. Butterfield, a grandson of a Vermont farmer who migrated to Michigan many years ago. He is one of our own kind, as it were, — one who, if not an honored alumnus, is an "M. A. C." man. Born on a western farm, brought up in a rural atmosphere, steeped in the belief that the trained mind should go with the trained hand, he comes to us a thorough convert to the idea that the study of agriculture, in all its varied branches and with its historic and storied associations, can be made the channel of cultural as well as vocational training; that a student trained under these influences, on a college farm, is more likely to seek and enjoy rural pursuits and a country life than one trained in the old school.

He comes to us, at thirty-eight years of age, out of the great, democratic,

vigorous west, a return in kind of what the east has sent to the west, full of virility and hope, and with large vision of the future. Although a quiet, unassuming man, he gives promise of being a forceful and successful president. May he be blessed with abundant strength and years to carry out his plans, and may his chief success lie in holding the college to the spirit and purpose for which it was founded; for we believe that this college and all the other land-grant colleges should strictly follow the provisions of the government act which created them, keeping agriculture, mechanic arts, manual training and military science well in the foreground; and that, if they do so, these thoroughly democratic State institutions will be tremendous factors in the development and redemption of this republic.

The Massachusetts Experiment Station.[1]

The agricultural experiment station as a regularly organized and recognized institution in Massachusetts dates from the year 1882. The present year, therefore, marks the completion of twenty-five years of work, and it seems especially fitting that in connection with this convention, which has the consideration of means of rural betterment for its prime object, we should both review its past and consider its present and future.

Though the experiment station in this State as an organized entity took its origin but twenty-five years ago, any survey of the past which should fail to recognize the fact that in a very real sense the experiment station in Amherst is as old as the college would not only be glaringly incomplete, but would be as well a grave injustice to the able, devoted and noble men, living and dead, who under peculiar difficulties yet labored zealously for the advancement of the bounds of knowledge of the laws which underlie farm practice.

No one who knows him will be surprised to learn that in this work our dear old Dr. Goessmann took a most prominent part. To mention even all the subjects which engaged his attention and upon which he wrote and talked instructively would occupy a very large share of my allotted time. I can but briefly refer to a few of the more important.

In these days, when the manufacture of sugar from the beet has become an established and rapidly growing industry in many parts of the United States, it is often forgotten to whose pioneer labors we have been so largely indebted. From his very earliest connection with the college we find Dr. Goessmann experimenting with the sugar beet, and studying the question as to the possibility of a profitable beet-sugar industry in this country. From 1870 to 1880 he was especially active in this direction, and his published reports and papers were numerous. While the results of his investigations led Dr. Goessmann to strongly advocate the beet-sugar industry in certain sections of the country and under the proper conditions, his discussions of the subject were always characterized by careful and temperate statements; and numerous early failures would have been avoided had the managers of the new undertakings more fully accepted Dr. Goessmann's conclusions.

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[1] By Dr. William P. Brooks, Director of the Massachusetts Agricultural Experiment Station; read at the fortieth anniversary, Oct. 2, 1907.

Of more general importance to the country at large was Dr. Goessmann's work in relation to fertilizers. He determined the manurial value of a large number of refuse substances and by-products, and pointed out better methods of conserving and using not only these but home-made manures and recognized fertilizers as well. To him also belongs the honor of having suggested and taken the most important part in the passage of the first law providing for fertilizer control passed in the United States. It is not extravagant to say that this law brought order out of chaos, and that with its subsequent amendments it has been worth untold sums to the farmers in the protection against fraud which it has afforded, while so wisely was it shaped and administered that it has almost equally served the interests of the honest manufacturers and dealers. Upon the Massachusetts fertilizer laws have been modeled the laws in very many of our States, so that in this particular direction Dr. Goessmann's influence has been felt all over the country.

Among other important investigations conducted by Dr. Goessmann prior to the organization of the experiment station, should be mentioned: his studies as to the effects of special fertilization upon the composition of fruits; his determination of the effects of girdling upon the quality of grapes; his recognition of the possible relation of fertilizers to certain plant diseases; his work in connection with the reclamation of the Green River salt marsh, in Marshfield; his determination of some of the chemical changes taking place in ensilage; and his chemical examination of sorghum and its products. He was associated with Stockbridge in the investigations which led up to the theory of special fertilization which bears the name of the latter, and in the study of the results of fertilizer application, by means of the lysimeter.

It is peculiarly appropriate at this time to recall to memory the fact that Professor Stockbridge not only contributed lavishly of time, ability and physical energy for the uplift of agriculture, but that he gave substantial financial aid as well. In 1878 he gave to the college for experiments in agriculture the sum of $1,000. Next to Goessmann, Professor Stockbridge undoubtedly took the most prominent part in the early experimental work at the college. His influence upon the agriculture of the State was great both because of unusual natural and acquired abilities and because he was from the farm, with which he always maintained the closest and most sympathetic touch.

Professor Stockbridge's experimental work which led up to the perfection of his system of special complete fertilizers for all our important crops is no doubt his best-known accomplishment. The idea underlying this system was, I believe, taken from Ville, but the elaboration and perfection of the system were based upon Professor Stockbridge's own experimental work. Professor Stockbridge, too, as long ago as 1880 called attention to the usefulness of frequent shallow culture as a means of conserving soil moisture, and was thus probably the very earliest to preach the "dust mulch" gospel. His experiments demonstrating the benefits of the "dust mulch," the sources of soil moisture and the origin of dew were characterized by much originality, and were carried out only by great sacrifices of personal ease. For months he rose at 3 or 4 o'clock in the morning in order to carry on his observations.

William S. Clark, the first active president of the college, deserves also to

be mentioned in the survey of the past. Although his work was less directly in touch with the farm than that of Goessmann and Stockbridge, it was nevertheless important, and his influence upon others was perhaps of even greater importance. President Clark was a man of tremendous enthusiasm and energy, and withal he had the spirit of the investigator, — the university spirit. To come in contact with him was an inspiration. No one can estimate the value of his influence in promoting throughout the institution, among faculty as well as students, the spirit of inquiry. President Clark's individual work during the early seventies showed marked originality, and the presentation of the results of his investigations into some of the phenomena of plant life at a meeting of the State Board of Agriculture held in Barre elicited the warmest encomiums from Louis Agassiz, who was present, and the statement that, had the Massachusetts Agricultural College done nothing throughout the period of its existence but produce that one paper, that alone would be richly worth every dollar which had been expended for the institution.

President Clark's experiments on the causes of the circulation of sap in plants, in which he was assisted in the device of the apparatus by Professor Peabody, and in which he enlisted the co-operation of a number of students, contributed important facts to the knowledge of that subject. He took a prominent part also in the sorghum experiments at the college, which settled the question as to whether Massachusetts should look to that plant for its sugar, and, incidentally, were the occasion of much interest and fun among the students.

The history of the experiment station as a regularly organized institution begins in 1882, when the Legislature framed an act establishing the Massachusetts Agricultural Experiment Station. Among the men most influential in promoting the passage of this act should be mentioned Dr. Goessmann, who was made the first director, and a number of prominent members of the Essex Agricultural Society. This office, by the way, he continued to fill throughout the entire period of the separate existence of this station. In thus establishing an agricultural experiment station in 1882, Massachusetts recognized the needs of agriculture some six years before Congress passed the Hatch act, providing for the establishment of such stations in each State and Territory; but we had been preceded in such action by Connecticut, New Jersey, North Carolina and New York.

The Massachusetts Agricultural Experiment Station had no organic connection with the Massachusetts Agricultural College. The act establishing it provided for its independent management and support. The amounts appropriated were at first moderate, but its usefulness was soon demonstrated, and the sums placed at its disposal were fairly adequate.

Very naturally the station was located in Amherst, where so much experimental work had already been done; and the needed land and buildings for a beginning were secured by a lease from the college, for a nominal consideration. The independent existence of the Massachusetts or State Experiment Station, as it came to be called, to distinguish it from the station later established under act of Congress, continued until 1895. The men most prominent in its work were Goessmann, Miles, Maynard, Humphrey and Lindsey.

The Hatch Experiment Station was established under the provisions of an

act of Congress applicable to all the States in 1887. It was named in honor of Representative Hatch of Missouri, the author and chief promoter of the passage of the act bearing his name, which provided for national support of agricultural experiment stations. By the provisions of this act the station must be a department of the college, and for this reason the money appropriated under the Hatch act could not be placed at the disposal of the existing State station, which, as has been indicated, was an independent institution. It did not seem expedient at that time to make the State station a department of the college, and so arose the somewhat anomalous condition, — two agricultural experiment stations side by side and practically in the same institution. Of the Hatch Experiment Station President Henry Hill Goodell was made director, which position he held until his death, in 1905. Under the organization adopted it was arranged that all the chemical work required in connection with the experiments of the Hatch station should be done in the State station, which received for this work the sum of $5,000 annually, which was one-third of the appropriation from the national government. Throughout the period of the existence of the two stations duplication of work was most carefully avoided, and the harmonious relations existing between the two organizations and the members of their staffs were never in any way disturbed.

Nevertheless, there soon came into existence a feeling that, in the interest of economy of administration and work and for the best results, the two stations should be united. This feeling strengthened with the passing years, and in 1895 the union was effected by act of Legislature, the combined stations taking the name of the younger organization. My part as chronicler of station history makes necessary the mention of but one other change, — the readoption of the name "Massachusetts Agricultural" instead of "Hatch." When the latter name was taken there already existed a Massachusetts station, and to avoid confusion some entirely different designation was needed. It was suggested that it would be a graceful and appropriate act to honor Representative Hatch, the author of the bill under which the stations were organized, by naming the new Massachusetts station after him. The reason for the name Hatch was never generally understood by the public, and ludicrous blunders were a frequent occurrence. No other State designated its station "Hatch," though all were equally indebted to the Missouri legislator. The uniform custom throughout the Union has been to apply the name of the State to the experiment station; and therefore to bring Massachusetts into line, and because the name of the State better characterizes the station, the change was provided for by act of our most recent Legislature, and the last annual report and the last four bulletins bear the imprint "Massachusetts Agricultural Experiment Station." With the consolidation of the original Massachusetts Agricultural Experiment Station with the Hatch Experiment Station Dr. Charles A. Goessmann, who had been director of the former, was made honorary director of the combined stations. He continued in charge of the chemical fertilizer and fertilizer control work until last July, when at the age of eighty he retired from active duties, and was made expert consulting chemist. The present incumbent, after acting in that capacity for a year, was made the director early in the year 1906.

The policy put into practice with the organization of the Hatch Experiment Station, of subdivision into distinct departments, — with one exception under the headship of the professor at the head of the corresponding department of the college, — is still followed. The head of the chemical department of the station is not directly connected with the educational work of the college. It is a question too broad and of too great importance to be entered upon, in the limited time at our disposal, whether in the best interests of station development and usefulness the policy of separate headship for college and station work along leading lines should not be more generally adopted.

Conscious as all those connected with station work have been and are that the ideals of the past even — to say nothing of the ideals of the present — have not been attained, a brief statement of some of our more important results must make it apparent that our work has touched and helped the farming public at many points. A complete summary of the work of the station is out of the question, and cannot of course be looked for in an address of this character. Some statement of the results obtained, however, seems desirable; and, though aware that injustice either in estimates of importance or through omissions will perhaps be done, is nevertheless presented in all modesty and sincerity.

Some of the things, then, that the farming public owes to the station are: better knowledge of methods of feeding our live stock, whether for milk, pork, beef, mutton, veal or eggs; far more definite information as to the nature and special adaptation of food stuffs; better knowledge of methods of feeding the crops of the field, garden and orchard; more accurate information as to the nature of manures and fertilizers, and the results to be anticipated from their use under the ever-varying conditions of practical operations; far wider and more accurate knowledge of the insects injurious to crops, and the discovery of much better means of destroying them; accurate knowledge of the nature and causes of many plant diseases, and the perfection of methods of prevention; a clearer insight into the relations of environment to the development and health of crops, which promises much in the direction of prevention of disease, — that ounce worth so infinitely more than the pound of cure; the discovery of the causes operating to destroy or injure so many of our shade trees, and the pointing out of methods of protection; and accurate reports as to the merits of new crops and new varieties.

Besides these and numerous other lines of work and discovery which might be mentioned, the station has tested and introduced to the agriculture of the country one crop — the Japanese barnyard millet — which has proved of enormous value throughout a large part of the United States. It is yearly grown upon thousands of acres, and one enthusiastic seedsman calls it "Billion-dollar grass," because, as he asserts, its general cultivation would increase our national wealth by that amount annually.

The station secured the passage of feed and dairy laws. It has helped to protect the public health by the analysis of well and spring waters. Finally, and among the most warmly appreciated of its benefits, the members of the station staff have annually answered several thousands of letters of inquiry. This line of work, though possibly not the most productive in the direction of

general advancement and uplift, is nevertheless most highly appreciated by the man who seeks advice or who is in trouble and needs a remedy.

With this very incomplete reference to some of the accomplishments of the past, let us consider the present. Let me endeavor to show you what this engine of modern civilization known as the agricultural experiment station is, what it has to work with and what it seeks to do.

The experiment station is a department of the college. It numbers on its working staff 21 men, besides several clerks and stenographers. Of these men, 13 give their entire time to the station; the others serve on the teaching force of the college as well. The organization of these men into divisions corresponding with the two great subdivisions in farming — viz., agriculture and horticulture, and with the leading sciences closely related to agriculture, — chemistry, botany, entomology, veterinary science and meteorology — is natural and in the interests of efficiency. These divisions, while pursuing somewhat distinct lines of work, co-operate to the fullest extent the one with the other in all cases where circumstances require such co-operation for the best results.

The experiment station makes free use of such portions of the college estate as are needed in its various lines of work. Its buildings have been provided in most cases by direct and special appropriations from the State. It is supported by both State and national appropriations, — about one-third of its present assured income coming from the State and two-thirds from the national treasury.

The work of the experiment station is of three distinct classes: investigation, control work and dissemination of information. Though most important among the lines of station work, and mentioned first, I shall speak of investigation last.

Control Work. — The control work of the station has for its object the protection of the purchaser of fertilizers and feeds and the user of certain classes of dairy apparatus. As related to fertilizers and feeds, the laws providing for this work require, briefly stated, that the seller "shall state what he sells and sell what he states." Those who remember the unsatisfactory character of the trade in fertilizers and feeds before the passage of these laws recognize their great value to the community. The honest manufacturer and dealer as well as the buyer being protected, the trade is infinitely more satisfactory, and attains much larger proportions than before the passage of these beneficent laws. The execution of these laws is the province of the chemical division of the station, each being under the immediate supervision of a separate section. The financial support of the fertilizer control work is in part provided for by the license fees which dealers are required to pay, the balance coming from the general funds of the station. The feed and dairy control work is covered by a special State appropriation. These branches of our work employ almost the entire time of five chemists.

It seems desirable that in the near future the station should be charged also with seed control. The character of the seeds offered is now in many cases uncertain and unsatisfactory. They should be guaranteed as regards

genuineness, freedom from weed seed and foreign matter, and percentage of germination.

Dissemination of Information.— The station carries its information to the public through a number of distinct channels, most important among which are distribution of its publications, correspondence, object lessons and demonstrations, exhibits at fairs and farming special trains.

The station publications are the principal means of reaching the public. Since organization the Massachusetts stations have issued 32 annual reports and 176 bulletins, besides a regular monthly meteorological bulletin and numerous circulars. These have treated a wide variety of subjects, and have been given a very wide distribution. Our regular mailing list at the present time includes some 20,000 names, and to each address all regular bulletins will be sent.

The correspondence of the station has been previously referred to. During the farmers' busy season the station will probably average 40 to 50 letters of inquiry daily. To answer many of these letters requires investigation or consultation of authorities, and this work makes a heavy draft upon the time of members of our staff. The work, however, is "present help in time of need," for every effort is made to return prompt replies,— in most cases the day of receipt of inquiry sees the reply dispatched. It is much appreciated, is rapidly growing, and unless it can be otherwise provided for must be continued.

In the line of object lessons and demonstrations upon private farms in different localities and upon our own grounds we have done something, but when resources in means and men permit, these lines of work may be much extended, for they surpass the printed page or the spoken word in clearness and strength of impression produced.

Farming special trains, of which we have operated one in co-operation with Vermont and New Hampshire, seem also to constitute a powerful agency for spreading information and driving home truths. These, however, are very expensive,— a heavy tax both upon the treasury and the time and energies of busy men. Without the most generous co-operation of the railroads and a larger staff such trains are at present impossible.

Investigation.— Experiments are suggested by the name adopted for this institution, and these are naturally regarded as its principal work; but that all experiments are not investigation is by no means always recognized. If, for example, the experiment station selects three supposedly similar and equal areas of land, and, having applied A's fertilizer to one, B's to another and left the third unfertilized, then plants to corn, cares for the three areas similarly, harvests and determines which has given the better product, it has tried an experiment. So, too, if two lots of animals are fed in contrasted ways and the results compared, this is an experiment. In neither case can the experiment be dignified by the title investigation. The results may have some value, or, on the other hand, they may be absolutely misleading, so numerous and so variant are the conditions which in either case determine the outcome. To know that A's fertilizer in the case supposed gave a better crop than B's, establishes a presumption perhaps that it is the better; but unless we have looked deeper

and can give the reasons, we have not made an investigation which deserves the name. Such an investigation as should establish the reasons must in the nature of things be difficult. It would require the closest scrutiny of every factor which helped to determine the product. The soil and the subsoil must be submitted both before and after cropping to close chemical and mechanical examination; the chemical character of the fertilizers must be exactly determined; the relations of climate to the outcome must be studied; the growth of the plants must be observed and recorded, and their composition determined. By such an investigation — the experiment being repeated until the result under known conditions can be foretold — the underlying causes and laws may be determined, and the discovery of these must have permanent value.

Up to the present time we have had perhaps too many experiments and too little investigation or research in the work of this, as of other experiment stations. We are seeking to improve our work in this direction. Such improvement is in full line with our ambitions, and is, moreover, both demanded by the most enlightened public sentiment and required under the last act of Congress relating to the stations.

The public will doubtless recognize that research which seeks to discover underlying laws is difficult, that time — very likely long periods of time — may be required, and, recognizing these facts, it will not become impatient for results. The discovery of underlying laws is essential to progress, and the work which leads to discoveries in this field, though its fruits may be slow in ripening and though it may at times seem impractical, will prove in the end most truly practical and to have been the best worth while.

The New System of Accounting.

The trustees' committee on finance, at its meeting at the college Tuesday, Nov. 19, 1907, passed the following votes relative to requisitions, care of moneys, apportionment, etc.: —

Requisitions, Bills and Receipts.

1. All orders for supplies shall be made on a uniform requisition, signed by the head of the department ordering, and countersigned by the treasurer. A copy of this requisition shall be filed with the treasurer at the time the order is given.

2. All bills shall be sent direct to the treasurer, who shall check same with requisition on file, verify the amount, and send it to the department for which the supplies were ordered. Upon *approval* and return of the bill to the treasurer, payment will be made.

3. All bills should be checked on receipt of goods and sent immediately to the treasurer, properly classified and approved.

4. All bills for payment by the treasurer must be fully itemized, containing the number of units, the rate per unit and the amount.

5. Pay rolls for all labor, with their proper classifications, shall be left at the treasurer's office by 9 o'clock on pay day. No employee will be paid for services except on the regular pay days, unless he is discharged.

6. No person shall draw the wages of any employee except upon the written order of the said employee.

7. Employees being unable to write, will make their mark, which shall be witnessed by an attaché of the college.

8. The treasurer shall in no case advance any money on the salary of an employee from the funds of the institution.

9. All receipts from every department of the institution, whether cash or collection, shall be turned into the treasurer's office, when amounting to $5 or more, by noon of the following day; when under this amount, by the Saturday forenoon of each week.

10. All receipts shall be fully itemized, containing name and address of the payer, number of units, rate per unit and amount.

11. The treasurer shall give a receipt for all moneys received, and all items received for collection. When items for collection have been paid, the treasurer shall notify such departments of the remittance.

TWENTIETH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

JANUARY, 1908.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
PERLEY A. RUSSELL.
SAMUEL C. DAMON.

THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Honorary Director and Consulting Chemical Expert.*
WILLIAM P. BROOKS, Ph.D.,	*Director and Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
JOSEPH B. LINDSEY, Ph.D.,	*Chemist.*
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
JAMES B. PAIGE, D.V.S.,	*Veterinarian.*
E. A. WHITE,	*Florist.*
HENRY J. FRANKLIN, B.Sc.,	*Assistant in Entomology.*
ERWIN S. FULTON, B.Sc.,	*Assistant Agriculturist.*
GEORGE H. CHAPMAN, B.Sc.,	*Assistant Botanist.*
EDWARD B. HOLLAND, M.S.,	*Associate Chemist* (research division).
ROBERT D. MACLAURIN, PH.D.,	*Assistant Chemist* (research division).
HENRI D. HASKINS, B.Sc.,	*Chemist in Charge* (fertilizer division).
PHILIP V. GOLDSMITH, B.Sc.,	*Assistant Chemist.*
JAMES C. REED, B.Sc.,	*Assistant Chemist.*
PHILIP H. SMITH, B.Sc.,	*Chemist in Charge* (feed and dairy division).
LEWELL S. WALKER, B.Sc.,	*Assistant Chemist* (feed and dairy division).
WILLIAM K. HEPBURN,	*Inspector.*
ROY F. GASKILL,	*Assistant in Animal Nutrition.*
CARL S. POMEROY, PH.B.,	*Assistant Horticulturist.*
EDWIN F. GASKILL, B.Sc.,	*Assistant Agriculturist.*
T. A. BARRY,	*Observer.*

REPORT OF THE DIRECTOR.

The work of the Massachusetts Agricultural Experiment Station during the past year has in the main followed the usual lines, but in most directions with constantly broadening scope and material increase in amount. The completion of Clark Hall, which will amply accommodate both the educational and the experimental work in the department of botany and vegetable pathology, will materially increase our facilities for investigation in this subject; but the interruption to work, made unavoidable by the necessity of moving and reinstalling the large amount of scientific apparatus and material, has necessarily reduced the amount of work in this department during the past year. The interruption has proved especially serious in connection with the study of problems relating to hothouse crops, as such work on the removal of department headquarters was necessarily discontinued in the old houses, and the new will not be completed until next spring. With this single exception, the work in all departments of the station has been prosecuted under conditions affording all the usual advantages.

Changes in Organization and in Staff.

The retirement from active administrative duties on the 1st of July of Dr. C. A. Goessmann, who from the date of its passage in 1884 has been charged with the execution of the fertilizer control law, and who was at the head of that branch of our chemical department carrying on general analytical and research work in connection with soils, manures, fertilizers and fertilizer problems, rendered reorganization in that department desirable. The chemical work of the station during the preceding eleven years had been divided between two distinct and entirely independent divisions, and carried on in separate laboratories. These divisions were known as the division of fertilizers and

fertilizer materials and the division of foods and feeding; the first, as has been stated, under Dr. C. A. Goessmann, and the second in charge of Dr. J. B. Lindsey. It was believed that organization under one head would secure a number of important advantages, as compared with the existing plan. Most important among the advantages which we have aimed to secure in reorganization were the following: —

1. Greater administrative economy.

2. Reduction in cost of equipment, apparatus and work.

3. The more complete separation of control from ordinary experimental and research work, thus making possible more accurate determination of the costs of each.

4. Improved facilities for research work in chemistry, through the creation of a research division, to which certain specially qualified men should give their entire time.

5. A saving in the time required for certain classes of control and analytical work, through concentration of forces alternately upon different branches of such work.

The organization adopted in the effort to realize these advantages is as follows: —

Department of Plant and Animal Chemistry.

Chemist: J. B. Lindsey, Ph.D.
Associate Chemist: E. B. Holland, M.S.
(*a*) Research division: E. B. Holland, M.S.
(*b*) Fertilizer division: H. D. Haskins, B.Sc.
(*c*) Feed and dairy division: P. H. Smith, B.Sc.

Besides the heads of divisions, four other analytical chemists, an inspector who collects samples of feeds and fertilizers and inspects dairy apparatus, a general laboratory assistant and one or sometimes two clerical assistants, one of whom is an expert stenographer, are regularly employed. The department also employs an assistant, who cares for the animals used in nutrition experiments and digestion work.

The chemist has general supervision of the entire work, and is responsible therefor, but is relieved of details, and will give most of his time to research problems. The associate chemist assists the chemist if required, or in his absence acts in his stead. The associate chemist, whose duties as such are usually nominal,

was placed at the head of the research division. Mr. Holland, who received this appointment, had already had much and successful experience in chemical investigation.

Mr. Haskins, who was put in direct charge of the fertilizer control, with responsibility to the chemist, has for several years been looking after most of the details of this line of work, owing to the advanced age of Dr. Goessmann, and is well qualified for the position, both by training and experience.

Mr. Smith, who, with responsibility to the chemist, was put in charge of the feed and dairy control division, had had several years of experience in such work, for which he had shown especial fitness.

No other changes in organization have been made during the year, and the station at the present time makes provision for the various lines of work in which it engages under the following departmental organization: —

Departments.	*Heads of Departments.*
Agriculture,	The DIRECTOR.
Horticulture,	F. A. WAUGH, M.S.
Plant and animal chemistry,	J. B. LINDSEY, Ph.D. E. B. HOLLAND, M.S., associate.
Botany and vegetable pathology,	G. E. STONE, Ph.D.
Entomology,	C. H. FERNALD, Ph.D. H. T. FERNALD, Ph.D., associate.
Veterinary,	J. B. PAIGE, D.V.S.
Meteorology,	J. E. OSTRANDER, C.E.

The only change in staff affecting a position of prominence in the station during the past year has been the retirement of Dr. Goessmann from active administrative duties at the head of the fertilizer division of our chemical department, already referred to. The station is fortunate in still being able to avail itself of Dr. Goessmann's services in the capacity of consulting chemical expert. His broad chemical knowledge and richly cultured mind and his long and varied experience render his advice of great value.

Dr. Goessmann at the age of eighty years looks back upon a career the memory of which must be to him a source of unusual satisfaction. It excites the profound admiration of all those familiar with his life, his character and his achievements. The

exercises held at the college last commencement in honor of his eightieth birthday made strikingly manifest the esteem and affection in which Dr. Goessmann is held by the alumni. The beautiful piece of stained glass, symbolizing some of the more prominent features of his life and work, which was then presented to him, though a triumph of affection and the designer's art, all too inadequately serves to express these sentiments.

An attempt to present an estimate of the value of Dr. Goessmann's service to the station and to the State and to set forth his part in the advancement of agricultural science would be out of place in this report; and yet brief mention of some of the more prominent features of his connection with this institution and the great agricultural movements with which his name has been identified seems appropriate. Dr. Goessmann took the chair of chemistry in the Massachusetts Agricultural College within a year of the date when its doors were first opened to students (1867), and this chair he filled, though of late with relatively few classes, until his retirement in June. Coming to this position with the best university training which Europe at that time could afford, he brought to his position the university spirit and method, and almost from the first he made his department in effect an experiment station in agricultural chemistry. Before Massachusetts had a regularly organized experiment station, Dr. Goessmann had carried out a large amount of experimental work, the results of which were published in reports of the college and those of the secretary of the State Board of Agriculture, as well as in numerous agricultural and scientific periodicals. Among the most important of these early investigations are those carried out to determine the possibilities of the beet sugar industry in this country. He was a pioneer in this field, and in his numerous publications clearly outlined the essentials for success. Of more general importance to the country at large was Dr. Goessmann's work in relation to fertilizers. He determined the manurial value of a large number of refuse substances and by-products. To him belongs the honor of having suggested and taken the most important part in the passage of the first law providing for fertilizer control passed in the United States. This law has been worth untold sums to the farmers, in the protection against

fraud which it has afforded, while so wisely was it shaped that under Dr. Goessmann's administration it has almost equally served the interests of honest manufacturers and dealers. Among other important investigations conducted by Dr. Goessmann prior to the organization of the experiment station should be mentioned his studies as to the effects of special fertilization upon the composition of fruits, his determination of the effect of girdling upon the quality of grapes, his recognition of the possible relation of fertilizers to certain plant diseases, his work in connection with the reclamation of the Green River salt marsh in Marshfield, his determination of some of the chemical changes taking place in ensilage and his chemical examination of sorghum and its products. He was associated with Stockbridge in his investigations which led up to the theory of special fertilization which bears the name of the latter, and in the study of the results of fertilizer applications through observations upon a lysimeter and analytical work connected therewith.

Upon the organization of an experiment station in Massachusetts, in 1882, Dr. Goessmann was made director. This position Dr. Goessmann held until 1895, when the Massachusetts or State station was combined with the station established as a department of the college under the Hatch act. At this time Dr. Goessmann was made honorary director, and was placed in charge of the chemical fertilizer and fertilizer control work, in which position he continued to serve the station with distinguished ability until his retirement the 1st of July last. He has taken with him in his retirement the good will, affection and esteem of all who have been associated with him, and all share in the hope that he will have many years yet of health, usefulness and happiness.

A number of minor changes in the station staff have been made during the year. These changes in many cases have been made necessary by the resignation of men who have left us for positions of greater responsibility and reward. The changes in staff have been as follows: —

E. Thorndike Ladd, M.S., promoted to the position of first assistant chemist, fertilizer division, in place of Edward G. Proulx, B.Sc., resigned.

Walter E. Dickinson, B.Sc., in place of E. Thorndike Ladd, promoted.

Carl S. Pomeroy, B.Sc., Ph.B., assistant horticulturist, in place of Charles P. Halligan, B.Sc., resigned.

George H. Chapman, B.Sc., assistant botanist, in place of Neil F. Monahan, B.Sc., resigned.

Upon the reorganization of the chemical department, which has been outlined, an additional chemist in the research division was employed. The successful candidate was Robert D. MacLaurin, Ph.D., who comes to us after thorough post-graduate courses in chemistry, and a brief but successful record in research work in the Rockefeller Institute in New York.

During the year Howard A. Parsons, dairy tester in the division of foods and feeding, has resigned, and during the past month we have received the resignations of Walter E. Dickinson and E. Thorndike Ladd, assistant chemists, both of whom resign to accept positions offering superior inducements. The positions thus made vacant have not as yet been filled.

The Mailing List.

Revision. — The revision of the mailing list referred to in the last annual report has been completed. It was found, as anticipated, that many of the addresses carried in the old lists were dead, either because of decease or removal of individuals. The postmasters throughout the State with rare exceptions willingly and heartily lent their aid in revising the lists. As soon as the revision was completed, stencils for use with the Elliott addressing machine were procured. The stencils have been arranged by post offices, which are placed alphabetically in the files, and under each post office the names are alphabetically arranged. As a result of this arrangement, several important advantages are secured : —

1. Publications as addressed can be readily made into bundles for the several post offices. This saves a great amount of time in handling and sorting at the local post office and costs us but very little additional labor.

2. Publications can be much more promptly sent out than was possible previous to this arrangement by post offices.

3. If desired, as for example, in case of an outbreak of injurious insects in a certain locality, bulletins or circulars can be readily sent to that locality.

The addresses of parties outside of Massachusetts are arranged alphabetically under the several states and countries.

Mailing List. — On completion of the revision, it was found that the number of live addresses was as follows : —

Residents of Massachusetts,	14,612
Residents of other States,	1,720
Residents of foreign countries,	169
	16,501

In addition, the station uses the Washington mailing list, which includes the addresses of those engaged in agricultural college and experiment station work. The total number of addresses in this list is about 2,000.

The station also uses the following special lists for meteorological reports, libraries, newspapers and exchanges : —

Meteorological,	260
Libraries,	158
Newspapers and exchanges,	520

During the past year an effort has been made to secure the addresses of all prominent cranberry growers. These addresses have for the most part been secured by writing to chairmen of the boards of selectmen in towns in the cranberry district, and to these men, most of whom prepared the lists promptly and without charge, the thanks of the station are due. The number of addresses in this list is 1,505.

During the past year we have added substantially 1,000 addresses to our general mailing list. These additions have been made in response to direct requests, and without solicitation on our part.

Publications.

Our rapidly growing mailing list has already greatly increased the costs of publication, and these costs must inevitably continue to increase with the constant additions to our lists. The time is not far distant when additional money for publications will be required. During the past year the publications of the station have been as follows : —

Publications during 1907.

Annual report: —

Contains reports of the director, treasurer and heads of departments, with papers on a large number of miscellaneous subjects. 207 pages.

Bulletins: —

No. 112. The Examination of Cattle and Poultry Foods, J. B. Lindsey. 60 pages.

No. 113. Analysis of Manurial Substances and Fertilizers and Trade Values, C. A. Goessmann. 30 pages.

No. 114. The Oriental Moth: a Recent Importation, H. T. Fernald. 15 pages.

No. 115. Preliminary Report on Cranberry Insects, H. J. Franklin. 15 pages.

No. 116. The San José Scale, H. T. Fernald. 22 pages.

No. 117. Trade Values and Fertilizer and Soil Analyses, C. A. Goessmann and H. D. Haskins. 22 pages.

No. 118. Molasses and Molasses Feeds for Farm Stock, J. B. Lindsey, E. B. Holland and P. H. Smith. 32 pages.

Technical, No. 3. Blossom End Rot of Tomatoes, Elizabeth H. Smith. 19 pages.

Complete Index to Bulletins and Reports of the Hatch Experiment Station, from 1888 to 1907. 48 pages.

Circulars: —

No. 1. Cotton-seed Meal, J. B. Lindsey and P. H. Smith. 8 pages.

No. 2. Cut Worms, H. T. Fernald. 2 pages.

No. 3. The Apple Maggot or Railroad Worm, C. E. Hood. 2 pages.

No. 4. Wire Worms, C. E. Hood. 2 pages.

No. 5. Root Maggots, H. T. Fernald. 2 pages.

No. 6. The Lecaniums, or Soft Scales, C. E. Hood. 2 pages.

No. 7. Ants, C. E. Hood. 2 pages.

No. 8. Bulletins of the Agricultural Experiment Stations in Massachusetts. 13 pages.

No. 9. Rules relative to Testing Dairy Cows. 6 pages.

No. 10. Sampling and Sending of Fertilizers, Soils and Feed Stuffs for Free Examination. 3 pages.

No. 11. Chemical Analysis of Soils, Wm. P. Brooks. 2 pages.

The complete index to the publications of the Hatch Experiment Station was very carefully prepared. It includes many cross-references, and will be found exceedingly valuable in connection with complete files of station publications from 1888 to 1907, inclusive. This bulletin will be sent, on application, to parties having files sufficiently complete to make it valuable.

Circular No. 8 gives a complete list of all the bulletins published both by the State and the Hatch Experiment Stations, as well as by the Massachusetts Agricultural Experiment Station, up to the date of its issue in July last. In this list publications which are still available for general distribution are indicated.

The other circulars are for the most part designed for use in answer to correspondence in relation to subjects with which they deal. They cover subjects on which the station receives frequent inquiries, and do so much more fully than would be possible within the limits of a letter.

The annual report of the station is printed by the State, and furnished only in an edition of 6,000. It will not be possible, therefore, to send this report even to all Massachusetts citizens whose names are on our mailing lists. Fifteen thousand copies of this report are, however, furnished to the secretary of the State Board of Agriculture, and are bound with his report, so that it is hoped the report in this form may reach all those who desire it. This plan of publication and distribution must, it seems, mean that many parties in the State receive duplicate copies of our reports. Clearly this is not economy, but we are for the present constrained by a State law to the method of publication outlined. An effort will be made during the coming session of the Legislature to secure a change in the law affecting our publications.[1]

Bulletins and Reports available for Free Distribution.

The supply of many of our reports and bulletins available for free distribution has been exhausted, but those in the following list will still be furnished on application : —

Bulletins : —

No. 33. Glossary of fodder terms.
No. 34. Fertilizer analyses.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 64. Analyses of concentrated feed stuffs.
No. 68. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.

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[1] Since writing the above report the Legislature has authorized the desired change.

No. 83. Fertilizer analyses.

No. 84. Fertilizer analyses.

No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.

No. 90. Fertilizer analyses.

No. 92. Fertilizer analyses.

No. 97. A farm wood lot.

No. 98. Inspection of concentrates

No. 99. Dried molasses beet pulp; the nutrition of horses.

No. 100. Fertilizer analyses; market values of fertilizing ingredients.

No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.

No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.

No. 105. Tomatoes under glass; methods of pruning tomatoes.

No. 107. Analyses of manurial substances forwarded for examination; market values of fertilizing ingredients; analyses of licensed fertilizers collected in the general markets.

No. 109. Analyses of manurial substances forwarded for examination; analyses of Paris green and other insecticides found in the general markets; instructions regarding the sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients for 1906.

No. 113. Fertilizer analyses.

No. 114. The oriental moth; a recent importation.

No. 115. Preliminary report on cranberry insects.

No. 116. The San José scale.

No. 117. Trade values and fertilizer and soil analyses.

Technical Bulletin No. 2. The graft union.

Technical Bulletin No. 3. The blossom end rot of tomatoes.

Special Bulletin. The coccid genera *Chionaspis* and *Hemichionaspis*.

Index to bulletins and annual reports of the Hatch Experiment Station published previous to June, 1895.

Index to bulletins and reports, 1888–1907.

Annual reports for 1898–1907.

Of many of the other bulletins of the station, a few copies still remain. These will be supplied only to complete sets for libraries. Circular No. 8, which gives a complete list of bulletins published by this station, will be sent on application.

The co-operation and assistance of farmers, fruit growers and

horticulturists, and all interested directly or indirectly in agriculture, are earnestly requested. Communications should be addressed to Massachusetts Agricultural Experiment Station, Amherst, Mass.

Asparagus Substation, Concord.

The work with asparagus in Concord, which is located on land leased from Mr. Charles W. Prescott, follows two distinct lines: (1) in co-operation with the Bureau of Plant Industry, of the United States Department of Agriculture, an effort to breed rust-resistant types of asparagus; (2) fertilizer experiments under the Adams fund in the effort to throw light upon the general question of the specific plant food requirements of this crop.

Breeding Experiments. — The Bureau of Plant Industry, through its agents in various parts of the world, has brought together a very large collection of varieties of asparagus. These have been drawn from all countries where the crop is grown. In most cases seed was procured. This seed was sown in a hothouse in Washington early last spring, and the young plants were sent in flats to Concord. This method of starting the plants was adopted in the belief that considerable time might thereby be saved. The number of varieties started was 36, but seed of several varieties was obtained from a number of sources, and 54 lots of seedlings were handled in this manner. The degree of success attending this method was only moderately satisfactory. The results varied widely with varieties, but in most cases there was a considerable percentage of loss, — greater no doubt than it otherwise would have been, on account of the extremely dry season. The young plants which survived made a fairly good growth. In addition to these varieties, our breeding plots now contain 35 other varieties, which have been brought together from various sources many of them having been collected by the Bureau of Plant Industry. Among the different varieties thus brought together in the same field may already be noted a very considerable variation in the apparent susceptibility to rust, and it may confidently be hoped that the objects in view in the experiment will ultimately, in large measure, at least, be attained.

Fertilizer Experiments. — The land selected for the fertilizer experiments lies in the Bedford Street district in the town of Concord. For a number of years previous to 1906 the field had been lying fallow, and was grown up with briers, small birches, weeds, etc. In preparation for the fertilizer experiments the field was cleared of brush and trees and plowed in the spring of 1906. It then received an application of fertilizers at the following rates per acre: —

Lime (tons),	½
Basic slag meal (tons),	½
High grade tankage (pounds),	600
Muriate of potash (pounds),	300
Nitrate of soda (pounds),	100

These with the exception of the lime, were mixed, evenly spread and harrowed in. The lime was applied by itself. In order to subdue the witch grass and other weeds, the field was harrowed a number of times during the late spring, and on May 15 it was sown to buckwheat. The buckwheat made a heavy growth, and was plowed under when fully grown. The field was then harrowed and sown to winter rye. This was plowed under in the early spring of 1907, and the asparagus set. The field is laid out in forty twentieth-acre plots, separated by dividing strips 5 feet and 1½ inches in width.

The dimensions of the plots are 129 feet by 16 feet 10½ inches. Each plot contains five rows. Each dividing strip contains one row set in the middle. The distance between plants in the rows is 2 feet 6 inches. The plants were raised by Mr. Frank Wheeler of Concord, and were from seed of the Giant Argenteuil variety, specially selected by Mr. Wheeler on account of apparent vigor and capacity to resist rust. These plants were exceptionally large and strong, and one year old at the time of setting. Practically every plant started, and the growth throughout the season was remarkably strong. Many of the plants attained a height in excess of 6 feet. All the details of the work were superintended or carried out by Mr. Charles W. Prescott, to whose skill and faithful attention, in connection with the thorough preparation which the land had received, the fine growth of the plants must be largely attrib-

uted. Numerous interesting variations in growth on the different plots were noted during the season, but it is yet too early to present the details of treatment, or to discuss the effects of the different fertilizer applications.

Cranberry Substations.

The station is carrying on work with cranberries along two distinct lines and in two different localities: (1) the study of cranberry insects in Wareham; (2) fertilizer experiments with cranberries in Falmouth.

Work on Cranberry Insects. — The station was fortunately able to command once more the services of Mr. H. J. Franklin for the study of problems connected with cranberry insects. Mr. Franklin spent the entire season, from the middle of April to the middle of October, in the cranberry district, most of the time in the town of Wareham. As the result of the season's work, our knowledge of cranberry insects has been greatly extended at numerous points, and the tentative conclusions reached as a result of the first season's work have been in many cases confirmed. A bulletin presenting the results of the first season's work, and containing advice as to the treatment to be adopted for the prevention of injury from the more important cranberry insects, has been issued during the year. This has been sent to all cranberry growers whose addresses we were able to obtain, — about 1,500. It has been found that the injury due to many insects can be for the most part prevented by a thorough destruction of vegetation around the shores of the bog, and suitable control of the water in flooding. Methods of spraying have been found to be fairly effective in some cases. The bulletin on cranberry insects, which gives all details, can still be furnished on application.

Fertilizer Experiments. — The fertilizer experiments in Falmouth are located in what is known as the Red Brook bog, belonging to Mr. N. H. Emmons of Boston and Falmouth. The present is the second season that these experiments have continued, and results which are believed to be of considerable significance have been obtained. The possibility of making exact comparisons between different fertilizer treatments has been in considerable measure reduced, owing to the unfortunate

breakage during last winter of one of the dikes, thus exposing a portion of the plots used in fertilizer experiments throughout the winter, while another portion of the plots was under water. It is not best, therefore, to undertake a discussion of the results in detail at this time. The following conclusions, however, appear to be warranted: —

1. The use of nitrate of soda greatly stimulates the growth of vines, and on bogs where vine growth is naturally free, this fertilizer should be used sparingly if at all. It has been noted, however, that the size of the berries is considerably increased wherever nitrate has been applied.

2. The application of acid phosphate appears to favor early maturity of the fruit, accompanied apparently by decrease in size. It would be premature to assert that this fertilizer element should not be used at all, but the indication is that the quantity needed is relatively small.

3. Among the fertilizer elements applied, the potash appears to have exerted the most favorable influence on the yield of fruit. Not only has it apparently increased the quantity, but it seems highly favorable to the development of a bright color, which gives the fruit an unusually attractive appearance. The fruit on the plots to which muriate of potash and acid phosphate were applied was characterized by experts as exceptionally solid and heavy, as well as of fine appearance.

4. The application of lime appears to have been unfavorable to fruitfulness.

Substation for Orchard Experiments.

Plans have been laid for extensive orchard experiments which will extend over a long period. A six-acre orchard of Baldwin trees set six years ago has been leased for ten years. The location is on the Bay Road in the southern part of the town of Amherst, on the farm of Myron C. Graves. The soil conditions throughout the entire tract appear to be exceptionally even for a tract of such size in this State, and it is believed the orchard affords very exceptional advantages for fertilizer, cover-crop and cultural experiments, which are the principal types of work in view.

Department Reports.

The reports of the heads of the different departments of the station will be found in later pages. The report of the agriculturist is elsewhere briefly summarized.

Department of Horticulture. — The report of the department of horticulture includes papers upon three distinct subjects: —

1. Notes on the propagation of apples. The experimental work upon which this paper is based was carried on with dwarf trees. The principal object of the experiment was to determine the influence of the scion on the character of the tree. The variety reported upon in greatest detail was the Baldwin, which was grafted upon three different stocks: the ordinary apple; Doucin; and Paradise. The method of measurement adopted shows a distinct influence apparently due to the variation in scion. The trees on the Doucin stocks were more uniform in shape and taller than those on the Paradise stocks; the trees on Paradise stocks were much stockier than on Doucin; while those on Doucin stocks were in turn much stockier than those on the ordinary stocks.

2. The physiological constant for the germination stage of cress. The methods which have been used in investigations for the determination of physiological constants are briefly outlined. The method reported upon, which is original, is described and compared with the earlier methods. The results with cress are reported in detail.

3. Variation in peas. This paper presents the results obtained by careful observations, and includes tabular records of a large number of observations which are carefully averaged. The results obtained are fruitful in suggestions as to the principles which should be followed in selection in breeding for improvement in any given direction.

Department of Plant and Animal Chemistry.— The report of the chemist presents first a numerical statement of the amount of analytical work accomplished during the year. This makes it apparent that the demands upon the station for work of this character are rapidly increasing.

The chemist in charge of the fertilizer control work, H. D. Haskins, reports the analysis of 45 more brands of fertilizers in

connection with such work than in 1906. Three hundred and fifty-eight samples in all have been analyzed and nearly 500 collected. Forty-one per cent. of the samples analyzed proved to be below the guaranteed composition in some one or more of the fertilizer elements, but in many cases the deficiency in one element was made up by an excess in one or more of the others. Twenty-one samples of complete fertilizers showed a commercial shortage varying from 79 cents to $13.50 per ton. This section of the report of the chemist presents complete tabular statements, showing the extent to which the fertilizers analyzed equaled or fell short of the guarantees.

The next section of the report presents an account of the execution of the feed law. Samples of feeds analyzed, with the single exception of cotton-seed meal, the quality of which was unusually poor, were found in general to be substantially as guaranteed. The report calls attention to the large amount of analytical work which is done without charge for private individuals in determining the quality of samples of milk and feeds. The results of the execution of the dairy law are briefly presented: 6.62 per cent. of Babcock glassware tested was condemned on account of inaccuracy; of the Babcock machines inspected, 37 in all, 2 were condemned.

The chemist calls attention to the great increase in the amount of work connected with the carrying out of official tests of pure-bred cows. Such tests are now conducted with animals of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeds. During the past year thirty-five yearly records and seventy records for shorter periods have been completed. Sixty-three cows are now undergoing tests. This work consumes a large amount of time, and, while the station is reimbursed for its money expenditure, it is found to be somewhat of a burden. The work is, however, without doubt important and useful, and until it is provided for in some other way the station will continue to supervise it.

The report of the chemist briefly presents the results of experiments completed with a view to determining the value for different classes of live stock of molasses and molasses feeds. He does not regard molasses as possessing advantages for dairy cows over the more common feeds. For fattening cattle, the

use of about 3 pounds daily can be recommended. For horses, a moderate amount of molasses is found to be useful as an appetizer and tonic; and the same is true for pigs. Molasses feeds are in general found to be rather high in price as compared with possible home mixtures, and would seem to possess no advantages as compared with such mixtures.

The results of experiments to determine the effects of soy beans minus the oil and of soy bean oil as food for dairy cows are presented. It was found that the meal, although exceptionally rich in protein, does not change the proportion of the different ingredients of milk. The oil temporarily increases the proportion of fat, and is found to affect the quality of the butter to a considerable extent, and on the whole unfavorably.

The report calls attention to experiments which are in progress on the effects of fat on milk secretion, and refers briefly to research work with soils from the different plots in Field A.[1]

It has been found that feeding molasses in large quantities depresses the digestibility of other foods used with it.

A section of the report of peculiar interest at this time, when the question of milk standards interests so many, deals with the chemical composition of milk. The average composition of the milk of most of the different prominent breeds, based upon a large number of analyses in different sections of the country as well as in foreign countries, is presented.

The effects of fat upon the composition of milk and butter fat and upon the consistency of butter are discussed by Dr. Lindsey. His experiments have shown that neither the proteid nor carbohydrate groups of nutrients when fed in normal amounts have any noticeable effect upon the proportion of different ingredients, nor on the character of butter fat. Any changes which occur as the result of variations in feed are usually consequent upon the kind and quantity of oil contained in the feeds used. Dr. Lindsey has found that when the feeds contain vegetable oils in excess of normal amounts the butter is soft. He finds that the flavor of butter depends primarily on cleanliness, the stage of lactation of the cow, the skill and care of the butter maker and the separator used.

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[1] For an account of the experiments on Field A, see report of the agriculturist, page 138.

The concluding section of the report of the chemical department is a paper by E. B. Holland, on a "Standard for Babcock Glassware." This paper presents a summary of the results of the tests of Babcock glassware carried out at the station since the passage of the dairy law in 1901. A standard for such glassware is proposed and carefully drawn, and rules for testing are presented. The standard and rules proposed by Mr. Holland have not yet been officially sanctioned by the American Association of Agricultural Chemists, but both have met the approval of Dr. Babcock, and they will probably be adopted.

Department of Botany and Vegetable Pathology. — The report of Dr. Stone, the head of the department of botany and vegetable pathology, contains papers upon a considerable number of important topics. Of especial interest is Dr. Stone's report concerning methods of separating light and inferior seeds and dirt from commercial or home-grown samples of seeds. The apparatus perfected in the department for this work shows much ingenuity in design, and the work is accomplished with great rapidity and accuracy. The methods used here are especially important for such seeds as tobacco and onions. As a result of the rejection of the inferior seed, a better stand of plants, substantially all of which, coming from sound, heavy seeds, are strong, healthy and disease-resistant, is obtained than is possible when commercial samples are planted. Work of this character is for the present done without charge. There has been a considerable increase in the number of samples sent in to be tested for germination. This work also is done for the present without charge.

The report calls attention to the unusual extent to which sun scald and sun scorch have prevailed among different varieties of trees. These troubles appear to be due primarily in many cases to the loss of a considerable proportion of the fibrous rootlets, which the botanist believes has been due to the excessively cold winters of a few years ago; and these troubles have shown more largely than usual during the past summer on account of the severe drought which prevailed. The extensive defoliation of many species of trees, notably elms, in the late summer or early fall, is believed to have been the result of the same cause.

The report calls attention to two apparently new diseases: one affecting asparagus, and apparently caused by a species of fusarium; and another affecting the peony, the cause of which has not been determined. No remedy for either of these troubles can at present be suggested.

During the past year the botanist has made careful comparisons between a number of combinations of fungicides and insecticides for potatoes. These experiments were carried out in connection with fertilizer work of the agricultural department which is designed to throw light upon the relative value for different crops of seven different potash salts.[1] There was little or no blight during the season, and all of the combinations tried seemed to possess nearly equal merit as insecticides. From the standpoint, however, of their ability to adhere to the foliage and their qualities in other respects, the botanist ranks the different combinations used in the following order: —

1. Soda bordeaux and Paris green.
2. Bordeaux and sodium benzoate.
3. Bordeaux and disparene (arsenate of lead).
4. Bordeaux and Paris green.
5. Copper phosphate and disparene.

In connection with the variation in fertilizers for the potato crop in this series of experiments,[1] an important influence on the prevalence of scab was noted. The proportion of badly scabbed tubers was much greater where potassium-magnesium carbonate was the source of potash than on any of the other plots.[2] The proportion of scabby tubers was smallest where the muriate and nitrate were the potash salts employed; but the difference between the proportion of scabby tubers on these fertilizers and on the other potash salts was relatively small.

The report of the botanist discusses mosaic diseases of tobacco and the tomato. He finds an important difference between the two diseases in two respects. Healthy tobacco

[1] For a full account of these experiments, see report of the agricultural department, page 145.

[2] The fact that scab is more apt to prove serious in soils which are alkaline has been frequently noticed. The potash-magnesia carbonate is a strongly alkaline fertilizer. Dr. H. J. Wheeler has frequently called attention to this point in reports and bulletins of the Rhode Island Experiment Station and elsewhere.

plants set in soil which contains decaying rootlets of diseased plants usually become affected with the disease. In the case of the tomato, a similar result does not follow. The report gives an account of methods tried for the purpose of determining the cause of the mosaic disease in the tomato. The botanist believes his experiments show that the disease is not caused by an excess of any of the fertilizer elements. The mosaic disease of tobacco may be so caused. The disease can be produced in tomatoes by severe pruning, and is at least associated with a deficiency of both the soluble and insoluble forms of catalase in the foliage.

The report of the botanist includes a suggestive paper on the factors which underlie susceptibility and immunity to disease in plants. This paper emphasizes the necessity of as full and perfect knowledge of the conditions essential for perfect development as possible, and advances the view that when our knowledge is sufficiently complete at this point it will be found possible in large measure to avoid many diseases which at present often prove highly destructive. We find the highest development of cultural methods among American gardeners and hothouse men. In the hothouse, where the climatic conditions are largely under control, there is but little trouble from disease when the conditions are fully understood and the management skillful. In the case of out-of-door crops, control of the climate being impossible, we may not be able so fully to avoid disease; but even with such crops, the most skillful adaptation of soil, manure and culture to the requirements of the crop will in large measure accomplish the same result.

Entomological Department. — The report of this department presents first a summarized statement showing the kind and amount of the work of the year. Brief accounts are also presented of some of the leading lines of experimental work. One of the most important of these is for the determination of the resistance of different crops to fumigation with hydrocyanic acid gas. These experiments are now complete for the cucumber, and similar tests for muskmelons have been begun.

Brief mention is made of experiments for the control of cabbage, turnip and onion maggots, concerning which, owing to causes beyond control, no definite results can yet be presented.

One of the most important lines of experiment during the past year has been the effort to determine the best methods of controlling thrips, which so often cause the blight of the onion. Spraying with kerosene emulsion appears to be the most promising method. The principal difficulty appears to be the production of a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. No perfectly satisfactory machine has yet been invented.

The report makes brief mention of experiments to determine better methods of destroying the San José scale, and the work with cranberry insects at Wareham. Further observations on the oriental moth are presented, and fortunately these indicate that this insect is not likely to become a serious pest. Attention is called to the fact that investigations have been begun to determine the exact geographical distribution of injurious insects. This work would seem to be particularly important, as Massachusetts is close to the northern limit of the distribution of some and near the southern limit of others. The report concludes with a presentation of observations upon the insects of the year.

Veterinary Department. — The report of the veterinarian presents an account of two serious outbreaks of disease among poultry. The first of these was European chicken cholera, which was found in two flocks. The identity of the disease was proved by careful microscopic investigations and inoculations. The owners of the affected flocks were promptly informed of the serious character of the disease, and, co-operating heartily with the veterinarian as they did, its prompt suppression was effected, and fortunately the disease did not spread from these flocks, which might easily have been centers of infection.

The other outbreak was found in a flock of chickens raised in brooders upon bare, sandy soil. It produced serious lesions of the feet and legs, and invariably proved fatal. The disease was found not to be infectious in character, and promptly disappeared when the chickens were moved to a more fertile location, where the growth of vegetation afforded some shade. It appears to have been due to the effects of the intense sunshine, aggravated by the character of the soil upon which the chickens

were kept. The disease did not affect chickens brooded under hens, although kept on the same kind of soil.

Meteorological Department. — The report of the head of this department calls attention to a number of important improvements which have been made in the equipment of the department during the past year. One of the most important of these is the setting up of apparatus over one of the manholes of our heat distribution system for melting snow as it falls. By means of this apparatus it will be possible to secure a more accurate record of the total precipitation, while by means of connections with recording apparatus in the office of the department the time of beginning and ending of storms can be determined with much exactness.

WM. P. BROOKS,
Director.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1906.

The United States Appropriations, 1906–07.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1907, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$7,000 00
Cr.		
By salaries,	4,568 74	4,731 74
labor,	4,202 04	899 32
publications,	1,858 60	–
postage and stationery,	591 39	–
freight and express,	329 50	31 77
heat, light, water and power,	239 16	–
chemical supplies,	122 85	152 99
seeds, plants and sundry supplies,	542 31	163 02
fertilizers,	107 85	96 48
feeding stuffs,	495 80	176 55
library,	134 82	141 94
tools, implements and machinery,	259 80	8 70
furniture and fixtures,	371 55	–
scientific apparatus,	210 04	439 92
live stock,	36 50	–
travelling expenses,	648 73	80 57
contingent expenses,	28 00	2 00
buildings and land,	252 32	75 00
balance,	–	–
Total,	$15,000 00	$7,000 00

State Appropriation, 1906–07.

Cash received from State Treasurer,	$16,500 00	
from fertilizer fees,	4,745 00	
from farm products,	1,267 21	
from miscellaneous sources,	6,800 42	
		$29,312 63
Cash paid for salaries,	$12,619 97	
for labor,	2,925 76	
for publications,	840 00	
for postage and stationery,	537 29	
for freight and express,	174 13	
for heat, light, water and power,	474 02	
for chemical supplies,	576 47	
for seeds, plants and sundry supplies,	338 48	
for fertilizers,	71 07	
for feeding stuffs,	454 90	
for library,	108 61	
for tools, implements and machinery,	286 84	
for furniture and fixtures,	848 17	
for scientific apparatus,	369 78	
for live stock,	129 05	
for travelling expenses,	1,479 51	
for contingent expenses,	57 50	
for buildings and repairs,	1,122 69	
Balance,	5,898 39	
		$29,312 63

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work in the department of agriculture during the past year has covered the usual field of experiment, and has been devoted chiefly to an effort to throw light upon some of the many problems connected with the use of manures and fertilizers. The number of field plots used in this work has been 318; the number of closed plots, 153; and the number of pots in vegetation experiments, 330. In the majority of our experiments, repetition from year to year, extending over a considerable period, is desirable in order that accidental variations may be as far as possible eliminated, and in order to bring out the variation in results connected with the varying character of our seasons. A detailed account of the results will be presented for only a small proportion of the experiments in progress.

No inconsiderable share of the time of the agriculturist is occupied in answering the many questions which annually come to the station on all matters pertaining to the practice of agriculture. The number of such inquiries answered during the past year has been 824. Experience indicates that inquiries of the same general character are likely to be sent in many times during the year, and we are therefore adopting in this department, in so far as circumstances warrant, the plan of sending circulars, with such comments as the statement of individual conditions seems to require, which has been referred to in the report of the director.

The more important results of the experiments reported in detail may be briefly stated as follows: —

I. — Experiment to determine the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of am-

monia and dried blood. This experiment was begun in 1890. The crop of this year was clover, sown in the standing corn in August of last year. On the basis of total yield (grass as well as clover included), the materials under comparison rank in the following order: nitrate of soda, dried blood, barnyard manure, sulfate of ammonia. The no-nitrogen plots gave a larger total crop than the sulfate of ammonia, and the clover in these plots was better than on any of the others. On the basis of increase in crop as compared with the product of the no-nitrogen plots, taking into account all the crops grown since the experiment began, the materials on a percentage basis rank as follows: nitrate of soda, 100; barnyard manure, 85.92; dried blood, 70.21; sulfate of ammonia, 45.36.

II. — Experiment to determine the relative value of muriate and high grade sulfate of potash. The crops on the basis of which comparison this year is possible were cabbages, rhubarb, raspberries, blackberries, asparagus, corn and squashes. The sulfate of potash gives the larger crops of raspberries and blackberries. For the other crops the muriate gives the larger crops; but the difference is unimportant except in the case of the asparagus, which is much better on the muriate than on the sulfate.

III. — Experiment to determine the relative value of different potash salts for field crops. The salts under comparison were kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The crop was potatoes. The salts, on the average of five trials for each, rank in the following order, as measured by the product of merchantable tubers: low-grade sulfate, muriate, nitrate, high-grade sulfate, silicate, carbonate, kainit. There was considerable scab, — a much greater amount on the carbonate than on the other potash salts.

IV. — Experiment to show the relative value for corn of special corn fertilizers, as compared with a mixture richer in potash. The special corn fertilizer gave a larger yield of sound corn. The fertilizer richer in potash excelled in the product of soft corn and stover. With an earlier spring and a hotter season, the proportion of sound corn produced on the fertilizer richer in potash would undoubtedly have been increased.

V. — Experiment to determine the relative value for production of corn of manure alone, as compared with a smaller application of manure and a moderate amount of sulfate of

potash. The larger application of manure alone gave a slightly higher yield of sound corn. The combination of manure and potash gave the higher yields of soft corn and stover. There was not much money difference in the value of the crops produced under the two systems, while the cost of the smaller application of manure and potash was at the rate of about $6 per acre less than the cost of the larger application of manure alone.

VI. — Experiment to determine the relative value, as measured by crop production, of a considerable number of phosphates used in quantities to furnish equal phosphoric acid to each plot. The phosphates under comparison were: fine ground, — apatite, South Carolina rock and Tennessee rock phosphates; Florida soft phosphate, basic slag meal, dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. The crop of the past season was mixed hay. The yields on the different phosphates varied relatively little. Even the plots which have received no phosphates during the eleven years the experiment has continued gave a yield at the first crop at the average rate of about 4 tons to the acre, while the highest yield obtained on any of the phosphates at first cutting was only 9,240 pounds.

VII. — Soil tests. The past season was the nineteenth during which the south soil test reported upon has continued. The results show the surpassing importance for the production of satisfactory corn crops of a liberal supply of potash.

VIII. — Experiment in the application of manures and fertilizers for grass. The materials used are: first, barnyard manure; second, wood ashes; and third, a combination of fine-ground bone and potash. The average yield of hay during the past season was at the rate of 5,005 pounds. The average for the fifteen years during which the experiment has been continued has been 6,296 pounds.

IX. —Winter versus spring application of manure on a slope. The crop of the past year was mixed grass and clover. The experiment was a test simply of the residual fertility from previous applications, as no manure was applied this year, as it was feared it would cause serious lodging of the crop. This judgment was justified by the result. The crop was extremely heavy, and considerably lodged in spite of the fact that manure was not applied this year. The differences in yield were small,

and did not indicate greater residual fertility where spring application of manure has been the rule than in the other plots.

X. — Experiment in the application of nitrate of soda for rowen. Owing to the deficiency of rainfall in the latter part of July and August, the rowen crop this year was small. The increase in crop resulting from the application of nitrate was not sufficient on the average to repay the cost of application.

XI. — Experiments in feeding hens. These indicate the great value of animal protein and fat and the injurious influence of fibre in the ration.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The materials under comparison in this experiment, all of which are used in such quantities as to furnish equal nitrogen per plot, are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. The field includes eleven plots, of one-tenth acre each, and, with few and unimportant exceptions, each plot has been manured in the same way since 1890. Each receives equal and liberal amounts of phosphoric acid and potash, the former in the form of dissolved bone black, the latter in the form of muriate, to plots 1, 3, 6, 7, 8 and 9, and in the form of low-grade sulfate to plots 2, 4, 5 and 10. Three plots have had no nitrogen applied to them in any form since 1884. The various materials are used on the other plots in such quantities as to furnish nitrogen at the rate of 45 pounds per acre. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two.

From a period very early in the history of this experiment, the plots to which sulfate of ammonia has been applied have shown a tendency to comparative unproductiveness, due apparently to unfavorable chemical or biological conditions. It was thought probable that application of lime would correct these faulty conditions, and 50 pounds of unslaked lime were applied to plot 6 in 1896. The entire field has been twice limed (in 1898 and 1905) since that date, at the rate of about 1 ton to the acre. In spite of these applications, the yield on the sulfate of ammonia plots, as will be noted, is still much below the average of the other plots.

The crops grown in this experiment previous to this year in

the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, and corn.

The crop the past year was alsike clover, considerably mixed, however, with grass, on all plots except those to which no nitrogen has been applied. The clover was sown in the standing corn on Aug. 6, 1906. When the corn was harvested in the fall of 1906, it was very apparent that the clover was relatively weak and unhealthy on all plots to which nitrogen has been applied during the progress of this experiment. The clover was thicker and more healthy on the three no-nitrogen plots than on any of the others. It was poorest on the sulfate of ammonia plots, and especially poor on the plots where sulfate of ammonia has been used in combination with muriate of potash. The relative condition of the clover on the different plots on the opening of spring was about the same as in the autumn, and as on most of the plots it was too thin for a good crop, 3½ pounds of alsike clover seed were sown per plot on April 3. This seed germinated fairly well, but of course the young plants from this seeding affected the rate of yield in the first crop but little. The rates of yield on the several plots and the sources of nitrogen and potash on each are shown in the following table: —

Yield of Hay and Rowen per Acre (Pounds).

Plots.	Nitrogen Fertilizers used.	Hay.	Rowen.
Plot 0,	Barnyard manure,	3,150	600
Plot 1,	Nitrate of soda (muriate of potash),	4,000	450
Plot 2,	Nitrate of soda (sulfate of potash),	3,900	600
Plot 3,	Dried blood (muriate of potash),	3,050	500
Plot 4,	No nitrogen (sulfate of potash),	3,400	650
Plot 5,	Sulfate of ammonia (sulfate of potash),	2,950	300
Plot 6,	Sulfate of ammonia (muriate of potash),	2,220	500
Plot 7,	No nitrogen (muriate of potash),	3,000	850
Plot 8,	Sulfate of ammonia (muriate of potash),	2,600	400
Plot 9,	No nitrogen (muriate of potash),	2,600	650
Plot 10,	Dried blood (sulfate of potash),	3,850	1,190

The fact that where the clover was relatively thin grasses came in to a considerable extent serves to obscure the effect of the different materials supplying nitrogen on the clover in the first crop. The second or rowen crop was very small on all plots. The principal reasons for this were two: (1) the first crop was cut late on account of bad weather; (2) there was but little rain during the latter part of the summer. The yield of rowen on the no-nitrogen plots, however, stands relatively much higher as compared with the yield on the other plots than was the case with the first crop. This difference was due to the fact that there was relatively little grass mixed with the clover in the rowen crop.

The average yields of this year on the several fertilizers are shown in the following table: —

Fertilizers used.	Pounds per Acre.	
	Hay.	Rowen.
Average of no-nitrogen plots (4, 7, 9),	3,000	717
Average of the nitrate of soda plots (1, 2),	3,950	525
Average of the dried blood plots (3, 10),	3,450	845
Average of the sulfate of ammonia plots (5, 6, 8),	2,590	400

As a result of all the experiments previous to this year, the materials furnishing nitrogen have produced crops in the following relative amounts: —

Relative Crop Averages.	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.63
Sulfate of ammonia,	91.08
Dried blood,	89.14
No nitrogen,	70.24

Similar averages for this year are as follows: —

	Per Cent.		
	Hay.	Rowen.	Hay and Rowen.
Nitrate of soda,	100.00	100.00	100.00
Barnyard manure,	79.75	114.29	83.71
Sulfate of ammonia,	65.57	76.19	66.81
Dried blood,	87.37	160.95	95.98
No nitrogen,	76.20	136.57	83.11

Combining the results of this year with those for previous years, on the basis of total yield per plot, the relative standing is: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	95.91
Dried blood,	91.35
Sulfate of ammonia,	84.13
No nitrogen,	70.96

Averaging our results on the basis of increase in crop as compared with the no-nitrogen plots, the relative standing for the entire period of the experiment, 1890–1907, inclusive, is as follows: —

Relative Increases in Yields (Averages for the Eighteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	85.92
Dried blood,	70.21
Sulfate of ammonia,	45.36

It will be noticed that, in spite of the fact that the mixture of grass with the clover, as has been pointed out, tends to obscure the effects of the fertilizer treatment on the latter, the combined yield of hay and rowen on the no-nitrogen plots this year is much greater than on the sulfate of ammonia, and practically the same as on barnyard manure. The yield of clover without doubt was actually greater on the no-nitrogen plots than it was on either the dried blood or the nitrate of soda. The fact has been for some time known that clovers, on account of their ability to draw nitrogen from the air under suitable conditions, are able to make relatively vigorous growth on soils to which no nitrogen is applied, provided these receive generous applications of such elements of plant food as lime, phosphoric acid and potash. Just why, however, the clover should do so much better, as was the case, on the no-nitrogen plots than on the other plots in this field is not at present apparent. It must be remembered that these other plots have received equal applications of lime, phosphoric acid and potash. It has been suggested that the failure of the clover to do well

on these plots must be due to residual nitrogen, which during the progress of the experiment has gradually accumulated. Calculation, however, shows that the crops harvested from these plots during the years that the experiment has continued must have removed from the soil larger quantities of nitrogen than had been applied.

The fact that the soil has been so heavily limed twice within recent years seems to preclude the conclusion that the relative failure of the clover is due to an acid condition of the soil; and, indeed, careful chemical analyses of samples taken last spring show that the soil of these plots does not, as a rule, contain appreciable quantities of free acid. We are unable, then, at present to account for the results obtained; but careful chemical and biological investigations will be carried out, with a view to throwing light upon this most important question.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

In this experiment, which was begun in 1892, muriate of potash is compared with high-grade sulfate, on a basis of such applications as will furnish equal actual potash per acre in connection with an annual application of fine-ground bone at the rate of 600 pounds per acre. Potash has been applied in different years in varying quantities. At first the applications were exceptionally heavy, — 350 to 400 pounds per acre of these salts were applied. Since 1900 each has been applied at the rate of 250 pounds per acre annually.

The crops during the progress of the experiment have embraced nearly all those common to this latitude. During the past year they have been: cabbages on two plots; asparagus, rhubarb, raspberries and blackberries, all on each of two plots; corn on four; and squashes on two. The rates of yield of the various crops on the different fertilizers are presented in the following table: —

Crops.	Fertilizers used.	Plot.	Yield per Acre (Pounds).		
Cabbages,	Muriate of potash,	11	39,522.70		
	Sulfate of potash,	12	38,461.50		
			Stalks.	Leaves.	
Rhubarb,	Muriate of potash,	13	30,733.90	24,526.00	
	Sulfate of potash,	14	30,685.30	26,168.20	
Raspberries,	Muriate of potash,	13	42.05		
	Sulfate of potash,	14	105.14		
Blackberries,	Muriate of potash,	13	365.38		
	Sulfate of potash,	14	738.76		
Asparagus,	Muriate of potash,	13	4,071.10		
	Sulfate of potash,	14	2,428.00		
			Hard.	Soft.	Stover.
Corn,	Muriate of potash,	15	63.56 bush.	6.05 bush.	7,943.80
	Sulfate of potash,	16	63.02 bush.	5.61 bush.	7,739.00
Corn,	Muriate of potash,	17	64.78 bush.	5.78 bush.	8,052.00
	Sulfate of potash,	18	64.94 bush.	7.10 bush.	7,781.40
Squashes,	Muriate of potash,	19	10,810.70		
	Sulfate of potash,	20	8,378.40		

Cabbages. — The yield of cabbages on the two potash salts this year is substantially equal. The crop on both was good. This result is not in agreement with results which we have usually obtained. As a rule, the sulfate of potash has given us larger crops of cabbages and better headed than muriate. The crop on this salt this year shows a slight inferiority in total yield. This difference is perhaps accounted for by the fact that the latter part of the summer was exceptionally dry. In seasons with less than normal rainfall and on light soils the muriate of potash often shows itself to be superior to the sulfate for crops which under opposite conditions give the best results with the sulfate.

Rhubarb. — With this crop, as with the cabbages, the results are substantially equal, whereas in earlier years the sulfate has given the larger yields. The explanation is perhaps that suggested in discussing the results with cabbages.

Asparagus. — It will be noticed that the yield of asparagus on the muriate of potash is much larger than on the sulfate. This is in accordance with the results which have previously been obtained with this crop. The customary practice of

depending largely upon muriate as a source of potash would appear, therefore, to be wise.

Raspberries and Blackberries. — The yield of both these fruits is exceedingly small, as both were seriously winter-killed. This year, however, as in earlier years, the yield on the sulfate of potash is much greater than on the muriate. This difference in yield is undoubtedly mainly a consequence of the fact that the canes produced where sulfate of potash is applied are better ripened and go through the winter better than where muriate is used.

Squashes. — The variety of squashes grown, Delicious, was planted on June 29, having been put in after two failures to get a satisfactory start of carrots on the plots occupied. The date of planting was, of course, far later than is desirable. Autumn frosts, however, held off later than usual, and a moderate crop was secured. The yield on the muriate was considerably greater than on the sulfate.

Corn. — Plots 15, 16, 17 and 18 were occupied by a variety test of sixteen different kinds of corn, forwarded for trial by the Bureau of Plant Industry of the Department of Agriculture. The results for the different varieties have not yet been fully worked up, and the total yields only are presented in detail. On one of the pairs of plots the muriate gives a considerably larger crop of grain; on the other the crops are substantially even. The muriate gives the larger yield of stover in both cases. The latter result is in accordance with those which we have usually obtained where these potash salts have been compared for corn. Earlier experiments have not shown any considerable difference in the value of the two salts for grain production, and the results of this year, not being in agreement on the two pairs of plots, cannot be regarded as especially significant. They were possibly somewhat affected by the fact that so large a number of varieties was included in the experiment; although an effort to equalize conditions was made by running the rows of the different varieties across the plots, so that each plot included the same quantity of each of the several kinds.

As of possible interest, it may be here stated that among the different kinds grown in this experiment, which included some

of those found in the experiments conducted by the department in various parts of the country to be the most promising, flint and dent varieties both being included, the largest yield was furnished by a variety of dent corn known as Minnesota No. 13 and the next largest by the Rustler White dent, a variety largely grown on the college farm in Amherst for the past two years, and obtained originally from a seedsman in Minnesota. Both of these varieties were fairly well ripened, although the cold, rainy spring and early summer months were highly unfavorable to the corn crop in this locality.

III. — Comparison of Different Potash Salts for Field Crops. (Field G.)

The general plan of this experiment is briefly stated in the nineteenth annual report, from which I quote : —

> This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash salts which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.

The experiment began in 1898, and the crops in the several years have been as follows : —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cow peas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.
1906. Potatoes.
1907. Potatoes.

As the results of last year indicated an important relation between the supply of potash in available form and the prevalence of blight, it was decided to plant the field to potatoes again in 1907, although it was recognized that this plan involved considerable risk that the crop would be seriously affected by scab, since, in spite of the fact that the seed planted in this field has always been thoroughly treated for destruction of the scab fungus, it had been noticed that the crop in a portion of the plots was somewhat affected by this disease. The amount of scab showing itself this year was unexpectedly serious, and this fact clearly indicates the soundness of the conclusion that potatoes should not as a rule be grown twice in succession upon the same field.

The variety of potatoes grown this year was Green Mountain. The seed was treated with formalin solution in the usual manner. On account of excessive rains throughout the early spring, planting was deferred until later than usual, — May 23. The crop was thoroughly cared for throughout the season, and sprayed twice with different combinations of fungicides and insecticides.[1] The yields per plot and the rates of yield per acre are shown in the following table: —

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 1, .	No potash, . . .	268.00	34.75	–	178.67	23.17	–
Plot 2, .	Kainit, ...	354.50	31.00	–	236.33	20.67	–
Plot 3, .	High-grade sulfate, .	367.00	33.50	–	244.67	22.33	–
Plot 4, .	Low-grade sulfate, .	369.50	23.00	–	246.33	15.33	–
Plot 5, .	Muriate, . . .	353.25	47.50	1.00	235.50	31.67	.67
Plot 6, .	Nitrate, ...	372.00	19.00	.75	248.00	12.67	.50
Plot 7, .	Carbonate, . . .	328.25	39.25	–	218.83	26.17	–
Plot 8, .	Silicate, ...	345.50	36.00	9.00	230.33	24.00	6.00
Plot 9, .	No potash, . . .	333.75	36.25	13.50	222.50	24.17	9.00
Plot 10, .	Kainit, ...	396.50	19.50	–	264.33	13.00	–
Plot 11, .	High-grade sulfate, .	386.50	27.50	.50	257.67	18.33	.33
Plot 12, .	Low-grade sulfate, .	400.00	27.75	.75	266.67	18.50	.50
Plot 13, .	Muriate, . . .	401.50	27.00	–	267.67	18.00	–

[1] For account of spraying experiments and results, see report of the botanist and vegetable pathologist, page 234.

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 14, .	Nitrate, ...	391.00	25.25	–	260.67	16.83	–
Plot 15, .	Carbonate, . . .	391.25	34.00	–	260.83	22.67	–
Plot 16, .	Silicate, ...	404.00	27.50	1.00	269.33	18.33	.67
Plot 17, .	No potash, . . .	301.25	33.00	1.50	200.83	22.00	1.00
Plot 18, .	Kainit, ...	339.50	13.00	.50	226.33	8.67	.33
Plot 19, .	High-grade sulfate, .	328.00	17.50	45.00	218.67	11.67	30.00
Plot 20, .	Low-grade sulfate, .	383.50	17.25	37.00	255.67	11.50	24.67
Plot 21, .	Muriate, . . .	333.00	15.25	56.00	222.00	10.17	37.33
Plot 22, .	Nitrate, ...	330.00	20.50	54.50	220.00	13.67	36.33
Plot 23, .	Carbonate, . . .	314.00	23.50	59.00	209.33	15.67	39.33
Plot 24, .	Silicate, ...	330.00	16.00	72.00	220.00	10.67	48.00
Plot 25, .	No potash, . . .	166.00	27.75	46.00	110.67	18.50	30.67
Plot 26, .	Kainit, ...	279.00	10.25	30.00	186.00	6.83	20.00
Plot 27, .	High-grade sulfate, .	370.50	11.50	29.00	247.00	7.67	19.33
Plot 28, .	Low-grade sulfate, .	366.75	23.00	6.00	244.50	15.33	4.00
Plot 29, .	Muriate, . . .	359.00	23.75	4.50	239.33	15.83	3.00
Plot 30, .	Nitrate, ...	336.00	24.25	2.00	224.00	16.17	1.33
Plot 31, .	Carbonate, . . .	340.00	37.00	–	226.67	24.67	–
Plot 32, .	Silicate, ...	372.50	28.50	–	248.33	19.00	–
Plot 33, .	No potash, . . .	198.00	25.00	–	132.00	16.67	–
Plot 34, .	Kainit, ...	284.00	14.50	–	189.33	9.67	–
Plot 35, .	High-grade sulfate, .	323.50	26.00	–	215.67	17.33	–
Plot 36, .	Low-grade sulfate, .	324.50	21.25	–	216.33	14.17	–
Plot 37, .	Muriate, . . .	297.50	33.00	–	198.33	22.00	–
Plot 38, .	Nitrate, ...	304.00	28.50	–	202.67	19.00	–
Plot 39, .	Carbonate, . . .	300.00	30.25	–	200.00	20.17	–
Plot 40,[1] .	Silicate, ...	226.00	33.25	–	150.66	22.17	–

The average yields of sound tubers under the varying fertilizer treatments were as follows: —

[1] Owing to a shortage in the available supply of silicate of potash, and the impossibility of procuring more, the quantity applied to this plot was only about one-sixth of the regular amount.

Potatoes.—Average Yields per Acre (Bushels).

Potash Salt.	Large.	Small.
No potash (plots 1, 9, 17, 25, 33),	168.93	20.90
Kainit (plots 2, 10, 18, 26, 34),	220.47	11.77
High-grade sulfate (plots 3, 11, 19, 27, 35),	234.73	15.47
Low-grade sulfate (plots 4, 12, 20, 28, 36),	245.90	14.97
Muriate of potash (plots 5, 13, 21, 29, 37),	236.57	19.53
Nitrate (plots 6, 14, 22, 30, 38),	235.07	15.67
Carbonate (plots 7, 15, 23, 31, 39),	223.13	21.87
Silicate (plots 8, 16, 24, 32, 40),	223.73	18.83

The no-potash plots this last year gave a yield much inferior to that produced on the plots receiving potash. The highest average yield was produced on the low-grade sulfate of potash: the lowest on the kainit. The differences between the different potash salts, exclusive of the kainit, are, however, relatively small. The full table showing the rates of yield per plot shows that there was considerable rot on about one-half of the plots. Dr. Stone failed to discover *Phytophthera infestans* on the foliage. The rot did not set in until the heavy rains of autumn. The variation in the proportion of decayed tubers in the different plots appears to be due to a difference in moisture conditions. There seems to be no well-defined influence on the proportion of decayed tubers which can be attributed to the potash salt employed. This year, as last, the foliage of the vines on the no-potash plots died much earlier than on any of the plots receiving potash. This premature death of the foliage may, however, have been due simply to lack of vigor consequent upon deficiency of potash in the soil, as Dr. Stone failed to find the characteristic fungi causing either the early or the late blight. It is probable, however, that in seasons with climatic conditions more favorable to the blight fungi they would attack the relatively weak foliage of plants growing where potash is deficient more seriously than they would the more vigorous foliage of better-nourished plants.

IV. — North Corn Acre. — Special Fertilizer *v.* Fertilizer Richer in Potash.

This experiment, which was begun in 1891, is designed to test the question whether the special corn fertilizers as offered in our markets are of such composition as seems to be best suited for the production of corn and mixed hay in rotation. The experiment occupies an acre of ground, and is divided into four equal plots, numbered from 1 to 4. Plots 3 and 4 were sown to millet during the first two years of the experiment, but with this exception their treatment has been the same as that of plots 1 and 2, 3 being a duplicate of 1 both as regards fertilizer application and crops produced, and 4 a duplicate of 2. The field has been in mixed grass and clover during three two-year periods, 1897–98, 1901–02 and 1905–06. With these exceptions, and with the further exception referring to millet noted above, corn has been the crop. Whenever the field has been put into grass and clover, it has been seeded in the standing corn of the previous year. Plots 1 and 3 have yearly received an application of fertilizers (a home mixture), furnishing nitrogen, phosphoric acid and potash at the rate per acre which would be supplied by 1,800 pounds of fertilizer having the composition of the average of the special corn fertilizers analyzed at this station. We have made but one change since 1899, as this average changes but little from year to year. The average composition of such fertilizers at that time was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizer used on plots 2 and 4 has been a home mixture richer in potash and much poorer in phosphoric acid than the mixture representing the average corn fertilizers offered in the market. The difference in the application of the fertilizer elements is made clear in the following table: —

Fertilizer Elements applied annually.

Plots.	Rates per Acre (Pounds).		
	N	P_2O_5	K_2O
Plots 1 and 3,	42.6	180	77.4
Plots 2 and 4,	47.0	50[1]	125.0

The materials applied annually to the several plots are as follows: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4[2] (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0[1]
Muriate of potash,	37.5	62.5

This field was limed in 1900 at the rate of 1 ton to the acre, and again this year at the same rate.

For the past two years the land has been in mixed grass and clover. The sod was plowed in May, and the corn, Rustler White dent, was planted on May 25. The rates of yield on the several plots and the averages for the two systems of manuring are shown in the following tables: —

Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (lesser potash),	59.75	4.24	6,400
Plot 2 (richer in potash),	56.00	7.10	7,060
Plot 3 (lesser potash),	57.75	5.75	6,760
Plot 4 (richer in potash),	52.00	8.25	6,720

[1] By mistake plots 2 and 4 received the same application of acid phosphate in 1906 as plots 1 and 3.

[2] Plot 4 this year received in addition 100 pounds of basic slag meal.

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	58.75	5.00	6,580
Plots 2 and 4 (richer in potash),	54.00	7.68	6,890

It will be noticed that the combination of fertilizers representing the special corn fertilizer gives an average yield of sound corn at the rate of about 4¾ bushels per acre more than plots 2 and 4. The yield of soft corn and of stover is, however, larger on plots 2 and 4. We have here an illustration of the well-known effect of a liberal supply of soluble phosphoric acid in hastening maturity, — an effect which was especially important during the past season, on account of the cold and rainy spring and the low average summer temperature. The greater weight of stover (field cured) on plots 2 and 4 may be in part a consequence of the fact that the crop was not so fully matured, although it has been repeatedly noted in our experiments that a liberal supply of potash promotes a heavy yield of forage. The addition of the basic slag meal to plot 4 has produced no apparent benefit during the past season.

V. — South Corn Acre. — Manure Alone *v.* Manure and Potash.

The objects in view in this experiment and the general plan are stated in the following quotation from my last annual report: —

The object in view in this experiment is to compare the crop-producing capacity of manure alone applied in fairly liberal amounts with a combination of a lesser amount of manure and a moderate quantity of a potash salt. An acre of land is used in the experiment. It is divided into four plots, of one-quarter acre each. Two of the plots (1 and 3) have received applications of manure only; the other two plots (2 and 4) have been fertilized by applications of lesser amounts of manure, together with a potash salt.

This experiment was begun in 1891. The crop for the first six years was corn. Corn was raised also in 1899 and 1900, and in 1903 and 1904. The field has been put into mixed grass and clover three times, being seeded in the summer preceding the first year of cutting in the corn crop.

Each time that the land has been seeded it has been cut twice annually for two years. The sod has then been broken in the fall for the corn crop of the following year. The years when the field has been in mowing are 1898 and 1899, 1901 and 1902, and 1905 and 1906.

Manure has been applied to plots 1 and 3 every year, at the rate of 6 cords per acre, with the following exceptions. No manure was applied in 1897, 1902 and 1905, and in 1898 the amount applied was at the rate of 4 cords per acre. The reason for the omission of manure in the years mentioned and for the smaller amount in 1898 was that experience indicated that its application would cause the grass and clover to lodge badly.

Manure has been applied to plots 2 and 4 as follows: in 1891 and 1892, at the rate of 3 cords per acre; in 1898, at the rate of 2 cords per acre; while in 1897, 1902 and 1905 no manure was applied. In all other years the application has been at the rate of 4 cords per acre. Potash has been applied to plots 2 and 4 at the rate of 160 pounds per acre of high-grade sulfate annually, except in the years when no manure was applied. In these years the potash also was withheld.

The entire field was limed in 1900 at the rate of 1 ton per acre. The manure used has been from well-fed milch cows, and has usually weighed about 3 tons per cord. Both manure and fertilizer were applied broadcast after plowing, and harrowed in.

The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields per Acre, 1907.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	65.50	6.00	7,080
Plot 2 (manure and potash),	60.40	7.78	7,508
Plot 3 (manure alone),	64.25	6.00	7,380
Plot 4 (manure and potash),	62.25	8.25	7,120

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	64.88	6.00	7,230
Plots 2 and 4 (manure and potash),	61.33	8.02	7,314

It will be noticed that the yield of sound corn is somewhat larger on the heavier application of manure alone than on the

combination of a lesser quantity of manure and the potash. On the other hand, the average yield of soft corn and of stover is greater on the combination of manure and potash. This result is in some respects analogous to that obtained with fertilizers on the north corn acre. In a more favorable season, the combination of manure and potash is likely to make a better relative showing. In estimating the significance of the results actually obtained, however, it should be kept in mind that, assuming the farmyard manure to cost $5 per cord applied to the field, the annual difference in cost of materials applied under the two systems of manuring has amounted to about $6 per acre, the application of the lesser amount of manure and the potash costing about that amount less than the larger application of manure.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

This experiment, comparing different phosphates, has been in progress eleven years. The phosphates under comparison are as follows: apatite (fine ground[1]), South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. Each is applied in such quantities as to furnish phosphoric acid at the rate of 96 pounds per acre. Three plots have received no phosphoric acid during the entire period of the experiment. All plots have annually received an application of materials furnishing nitrogen and potash and in equal amounts, nitrogen being furnished at the rate of 52 pounds and potash at the rate of 152 pounds per acre. In the case of a few crops requiring especially high manuring (onions and cabbages), a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. The crops grown in this field in the order of succession have been as follows: corn, cabbages, corn, — in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, cabbages, and mixed grass and clover for two years. The plots were seeded to mixed grass and clover in the spring of 1905; the present is therefore the third year that they have been in grass. The yields and the gain or

[1] Not used either in 1906 or 1907, as it is not offered by dealers.

loss as compared with the no-nitrogen plots are shown in the following table : —

Plots.	Fertilizers used.	Yield per Plot (Pounds).		Yield per Acre (Pounds).		Gain or Loss (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	No phosphate, ...	1,050	50	8,400	400	-	-
Plot 2,	Apatite, ...	1,100	63	8,800	504	867	+71
Plot 3,	South Carolina rock phosphate,	1,060	62	8,480	496	547	+163
Plot 4,	Florida soft phosphate, . .	1,060	50	8,480	400	547	+67
Plot 5,	Phosphatic slag, . . .	1,045	52	8,360	416	427	+83
Plot 6,	Tennessee phosphate, . .	1,005	41	8,040	328	107	—5
Plot 7,	No phosphate, ...	1,020	30	8,160	240	-	-
Plot 8,	Dissolved bone black, . .	1,150	61	9,200	488	1,267	155
Plot 9,	Raw bone, ...	1,155	63	9,240	504	1,340	171
Plot 10,	Dissolved bone meal, . .	1,145	63	9,160	504	1,227	171
Plot 11,	Steamed bone meal, . . .	1,040	70	8,320	560	387	227
Plot 12,	Acid phosphate, . . .	1,005	75	8,040	600	107	267
Plot 13,	No phosphate, ...	905	45	7,240	360	-	-

It will be noted that the first crop was exceptionally heavy. The large yield was without doubt due in considerable measure to the weather conditions, which were exceptionally favorable for hay in this locality. Such yields, however, must have been impossible but for the liberal fertilization which the field has received.

It will be noticed that even the no-phosphate plots have given a yield averaging nearly 4 tons per acre at the first cutting. The highest yields were afforded by the dissolved bone black, raw bone and dissolved bone meal, between which there was relatively little difference ; but the fact that the yield on the plot receiving apatite was but little inferior to the yield on these best plots, while with such crops as cabbages in past years it has been hardly one-half as great, taken in connection with the relatively large yield of the no-phosphate plots, sufficiently emphasizes the relative unimportance of supplying phosphoric acid in soluble form for such a crop as mixed grass and clover. The soluble phosphates in this experiment when cabbages were the crop gave yields about two to five times as great as the no-phosphate or the insoluble phosphate plots, while this year the

differences are comparatively insignificant. The yield of rowen this year was exceptionally small, and for the same reasons as those which have been mentioned in discussing the results on Field A, viz.: late cutting of the first crop, and protracted drought during the latter part of the summer.

VII. — Soil Tests.

Soil test work has been continued upon the two acres which have been used so long in work of this description. The plan is the co-operative method adopted in convention in Washington in 1889. The crops of this year have been, on one acre, corn; on the other, mixed grass and clover. The latter was sown this spring, and the crop, which was considerably mixed with weeds, was not weighed separately for the different plots. No detailed report will be made, therefore, for this acre. In this soil test work the kinds of fertilizers and the rates of application per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 800 pounds.
Lime, 800 pounds.
Manure, 5 cords.

Soil Test with Corn (South Acre). — This acre has been used in soil tests for nineteen years, beginning in 1889. The field was limed, each time at the rate of 1 ton per acre, in 1899 and 1904. Early in the spring of the present season it received another application of lime, at the rate of 1,000 pounds per acre of R. R. agricultural lime, manufactured by the Rockland-Rockport Lime Company. This was spread after plowing, as in previous years, and harrowed in. The crops for the successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover. The crop for the present season was corn, which is, therefore, the ninth corn crop grown in the field since the experiment began in 1889. Three times during this period

the field has been put into mixed grass and clover, each time for two years. The third grass and clover period ended last year. The sod, however, was not turned until last spring. The soil was well prepared, but, owing to the cold and rainy spring, the crop, Rustler White dent, was not planted until June 1. The character of the past season, as has been pointed out in another section of this report, was rather unfavorable for corn. The following table shows the fertilizers used on the several plots, the rates of yield and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1907.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels).	Stover (Pounds).	Corn (Bushels).	Stover (Pounds).
Plot 1, .	Nitrate of soda, ...	1.00	720	—1.00	—280
Plot 2, .	Dissolved bone black, . . .	.81	700	—1.19	—300
Plot 3, .	Nothing, ...	2.00	1,000	-	-
Plot 4, .	Muriate of potash, ...	23.31	6,000	+21.23	+4,967
Plot 5, .	Lime, ...	1.25	900	—.92	—167
Plot 6, .	Nothing, ...	2.25	1,100	-	-
Plot 7, .	Manure, ...	72.50	6,900	+70.25	+5,800
Plot 8, .	Nitrate of soda and dissolved bone black.	10.06	2,500	+6.25	+1,400
Plot 9, .	Nothing, ...	3.81	1,100	-	-
Plot 10, .	Nitrate of soda and muriate of potash.	31.13	5,400	+27.46	+4,400
Plot 11, .	Dissolved bone black and muriate of potash.	30.13	6,500	+26.61	+5,600
Plot 12, .	Nothing, ...	3.38	800	-	-
Plot 13, .	Plaster, ...	7.75	1,200	+4.37	+400
Plot 14, .	Nitrate of soda, dissolved bone black and muriate of potash.	38.31	5,500	+34.93	+4,700

It will be noticed that the yield on the nothing plots is excessively small, amounting on the average to but little more than 2½ bushels of shelled corn per acre and about 1,000 pounds of stover. The use either of nitrate of soda or of dissolved bone black alone gives absolutely no increase; indeed, the crops on these single fertilizer materials were smaller than on the nothing plots. On the other hand, the use of muriate of potash at the rate of 160 pounds per acre (for this, the nine-

teenth year during which the land has been fertilized only with this material) gives an increase at the rate of rather over 20 bushels of corn and nearly 2½ tons of stover per acre. The tables which follow bring out the effects of the different fertilizer elements when used alone or in different combinations with great clearness: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	−1.00	+7.44	+6.23	+8.32	+5.25
Stover (pounds),	−280.00	+1,700.00	−567.00	−900.00	−11.75

Value of increase,	$3 89[1]
Financial result (loss),	11

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels),	−1.19	+7.25	+5.38	+7.47	+4.73
Stover (pounds),	−300.00	+1,680.00	+633.00	+300.00	+578.00

Value of increase,	$5 89
Financial result (gain),	3 01

	Results of the Addition of Potash to —				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels),	21.23	28.46	27.80	28.68	26.54
Stover (pounds),	4,967.00	4,680.00	5,900.00	3,300.00	4,712.00

Value of increase,	$38 75
Financial result (gain),	35 15

[1] The financial calculations in these tables were based on the following prices: —

Nitrate of soda,	$50 00 per ton.
Muriate of potash,	45 00 per ton.
Dissolved bone black,	18 00 per ton.
Lime,	6 00 per ton.
Plaster,	10 00 per ton.
Manure,	5 00 per cord.
Corn,	75 per bush.
Stover,	8 00 per ton.

	Results of the Addition to Nothing of —			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels), ...	—.92	+70.25	+4.37	34.93
Stover (pounds), ...	—167.00	+5,800.00	400.00	4,700.00
Value of increment, . .	-	$75 89	$4 88	$45 00
Value of decrease, . . .	$1 36	-	-	-
Financial result, . . .	3 76 (loss).	50 89 (gain).	88 (gain).	34 52 (gain).

The first of these tables shows that, although nitrate of soda, when used alone, does not increase the crop, it gives a small increase when used in connection with either of the other fertilizer materials alone or with the two together. The nitrate when used in connection with either potash alone or with potash and dissolved bone black has apparently at the same time increased the yield of grain and decreased that of stover. No explanation of this result can be offered. We have, however, figured results on the weights of field-cured stover, and it is possible that variation in moisture content obscures real effects, although this is not believed to be the case, as similar results have been obtained in other years.

The second of these tables shows that, while phosphoric acid used alone gives no increase, it gives a moderate increase both in grain and in stover when used with either of the other fertilizer materials or with both. It will be noticed that on the average the value of the increase in crop due to the use of the phosphate exceeds the cost of that fertilizer.

The third table shows the results obtained by the use of potash. The fact is at once evident that this is the dominant element for the corn crop in this soil. It will be noted that even when used by itself it gives a large increase. It seems surprising that the increase produced when the potash is used in connection with both the other fertilizer elements does not compare more favorably with the increase when it is used alone. We have, it is true, a somewhat larger increase in grain. On the other hand, the increase in stover is not as great as that produced when the potash is used alone. The value of the increase produced by the use of potash greatly exceeds the cost of this fertilizer element.

The last of the four tables under consideration shows the results, as compared with the nothing plots, of the use respectively of the lime, the manure, the plaster and the complete fertilizer. The lime used alone proves absolutely valueless. The manure gives a heavy crop, and its use is highly profitable. Plaster produces a small increase. Complete fertilizer produces a fair crop, and is moderately profitable.

Attention is here called to the fact, previously noted in referring to this field, that the object in view is not to demonstrate the possibility of producing large crops, but to bring out the specific effects of long-continued use of the different fertilizer elements and fertilizer combinations. A more profitable crop could undoubtedly be produced on fertilizers by making a more liberal application. The possibility of doing this is sufficiently demonstrated by the results obtained in raising corn in alternation with mixed mowings on fertilizers alone on the north corn acre,[1] where highly profitable crops have been yearly produced. This soil test work, taken in connection with other experimental work, a part of which is referred to in this report, and in connection with results obtained in various parts of the State, certainly indicates the desirability of a more general and larger use of fertilizers rich in potash in the production of the corn crop.

VIII. — Experiment in Manuring Grass Land.

The plan of this experiment will be understood from the following outline, quoted from my sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year, fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

[1] See page 149.

The past season in this part of Massachusetts was in general favorable to a large yield of hay at the first cutting, but the rowen crop was in most fields much smaller than usual, on account of the deficiency of rainfall during the latter part of July and August. It will be noted, however, that the yields in this field during the past season were considerably under the general average for the entire period of the experiment. The results for each of the systems of manuring is shown in the table: —

Fertilizers used.	Yield per Acre.		
	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,517	1,205	4,722
Bone and potash,	3,903	1,728	5,631
Wood ashes,	3,083	1,579	4,662

The average for the entire area this year was 5,005 pounds. The average from 1893 to 1906, inclusive, was 6,389 pounds of well-dried hay per acre annually. The average to date, including the crop of the past season, is 6,296 pounds. A comparison of the average yield throughout the entire period for each of the several systems of manuring will be of interest. These averages are as follows: —

	Pounds per Acre.
When top-dressed with manure,	6,525
When top-dressed with wood ashes,	5,965
When top-dressed with bone and muriate,	6,284

In each of plots 1 and 2 two different mixtures of grass seeds are under comparison on equal areas. One of the mixtures in each plot is the usual farmer's mixture of timothy, redtop and clovers. The other mixture contains a considerable variety of seeds, but tall and meadow fescues are the predominating species. These plots were seeded in 1902. During the first few years the timothy mixture gave the larger yields. During the past season the fescue mixture has given the larger total yields on both plots. The differences, however, are not large.

IX. — Experiment in the Application of Manure.

Full details with reference to the plan followed in this experiment will be found in the nineteenth annual report. Briefly stated, the object is to compare results obtained through spreading manure as it is removed from stables during the winter with the practice of storing in a heap in the open air until spring and then spreading. The field which is used in this experiment slopes quite rapidly toward the west. The experiment was begun in 1899; the past season, therefore, is the ninth during which the experiment has continued. The crop this year was mixed grass and clover, sown in the standing corn of the previous year. No manure was applied either in winter or spring this year, as it was apparent that the land, which has been manured annually at the rate of 6 cords to the acre for the past eight years, would produce as rank a growth as was desirable. The rates of yield per acre and the relative standing of the several plots are shown in the following table: —

Grass and Clover. — Actual Yields (Pounds per Acre).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	6,885	973.3	6,903	1,081.5
Plot 2,	6,885	1,261.7	6,795	1,135.5
Plot 3,	5,948	1,279.7	6,363	1,117.5
Plot 4,	6,633	973.3	6,164	1,027.4
Plot 5,	6,327	558.8	6,020	973.3

Grass and Clover. — Relative Yields (Per Cent.).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	100	100	100.26	111.12[1]
Plot 2,	100	100	98.69	90.32
Plot 3,	100	100	106.98	87.32
Plot 4,	100	100	92.93	105.56
Plot 5,	100	100	95.15	174.18

[1] These yields of rowen less accurately measure the fertility than the first crop, for the grass and clover both were unevenly killed in spots by the lodging of the first crop.

The crops of this year are of course a measure only of the residual fertility from previous manuring. The yield was heavy, but, as will be noticed, it was not uniformly favorable to either system of application, although on the whole the plots to which the manure has been applied during the winter gave the heavier yields. These experiments to date do not support the view that the waste following winter application of manure is sufficiently serious to offset the saving in labor, as compared with the system of double handling which storing in heaps to be spread in the spring involves. Our records indicate that spring application costs at the rate of about $4.80 per acre more than the single handling, where the manure is spread when hauled during the winter.

X. — Nitrate of Soda for Rowen.

This experiment was designed to determine whether the application of nitrate of soda made soon after the first crop is cut will give a profitable increase in rowen. The field, although originally seeded to pure timothy in 1897, now gives crops largely mixed with clover. The total area is a little more than three acres. For the first crop we apply fertilizers at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds.

For the purpose of the experiment with nitrate of soda, eight equal plots have been laid off, each containing almost exactly one-third of an acre. Alternate plots have annually received a top-dressing of nitrate of soda after the removal of the first crop during the past seven years. For the past four years, in order to facilitate the more even distribution of the nitrate, it has been mixed with sufficient basic slag meal to furnish an application of the latter at the rate of 400 pounds per acre; and to equalize conditions on the alternate plots to which no nitrate is applied, the slag meal is applied to all of these at the same rate. The results obtained the past season are presented in the table: —

Nitrate of Soda for Rowen.

Plots.	Fertilizers used (Rates per Acre).	Yields (Pounds).	Increase per Acre (Pounds).
Plot 1,	Slag meal, 400 pounds,	1,295	–
Plot 2,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	1,584	312
Plot 3,	Slag meal, 400 pounds,	1,249	–
Plot 4,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	1,493	160
Plot 5,	Slag meal, 400 pounds,	1,417	–
Plot 6,	Slag meal, 400 pounds; nitrate of soda, 200 pounds,	1,712	417
Plot 7,	Slag meal, 400 pounds,	1,173	–
Plot 8,	Slag meal, 400 pounds; nitrate of soda, 250 pounds,	2,285	1,112

The differences this year, although indicating a beneficial effect in every instance from the application of nitrate, are comparatively small except on plot 8. This is doubtless accounted for in large measure by the extreme drought which prevailed during the latter part of the summer. At current retail prices for nitrate during the past season its application did not prove profitable in any instance.

XI. — Poultry Experiments.

The poultry work of the past year has consisted in a repetition of the experiments in feeding for eggs which were carried out during the two preceding years. The general results of these experiments cannot perhaps be better expressed than in the following words, quoted from the nineteenth annual report: —

> The experiments had indicated: first, that, provided fat is abundant in the ration, high protein content is not essential; second, that, if the fat content of the ration is low, a large proportion of protein in the feeds used appears to be much more essential; and third, that a large proportion of fiber in the ration used is unfavorable to a good egg product.

The fowls used in the experiments of the past year were, as in previous years, pullets of our own raising. Carefully matched flocks were kept, as in former years, each in a house by itself, all of the houses being precisely similar in general dimensions and construction. The results of the past season's work are confirmatory in every particular of the results previously obtained. A somewhat full account of our experiments will be

published in a bulletin which will be issued in the near future. I call attention here, therefore, only to what seem to be some of the more important practical conclusions. In estimating the reliability of these conclusions, it should be remembered that they are based upon results (on the whole in exact agreement throughout) which have been obtained in these long-continued experiments. These practical conclusions are as follows: —

1. When fat is abundant in the rations used in feeding fowls, a satisfactory egg product can be obtained by the use chiefly of grains which are relatively low in protein and high in carbohydrates. This means that corn may safely constitute a large proportion of the grain fed to laying fowls, and that it is not necessary, in order to secure a satisfactory egg product, to pay the higher prices usually demanded for wheat. It seems wiser to depend chiefly upon animal foods, such as beef scraps of good quality, to supply a fairly liberal proportion of protein and to enrich the ration in fat, using corn in connection with the scraps as the chief whole grain. A little wheat may be desirable, for the sake of variety, but to feed wheat as a source of protein seems unnecessary. Vegetable protein is not equal in value for egg production to protein derived from animal substances.

2. If, on the other hand, the combination of feeds used is low in fat, then a ration which furnishes abundant protein will prove considerably superior to one low in protein. If, for example, a dried animal meal from which the fat has been largely extracted, or such material as milk meal (milk albumen) made by the evaporation to dryness of separator skimmed milk low in fat, be used as sources of animal protein, then the combination of foods, including wheat in large quantity and therefore supplying protein in relative abundance, will give more eggs than a combination of foods in which corn, which furnishes less protein, is the principal grain. It has been clearly shown in investigations with domestic animals that in the process of digestion and assimilation the protein of the food may undergo changes resulting in the production of fat. If, as seems probable, the laws controlling metabolism in the digestive and assimilative processes of our domestic fowls are similar to those in the larger domestic animals, we find in this fact an explana-

tion of the difference in relative importance of wheat and corn in the rations of fowls with high and with low fat content. The body temperature of the domestic fowl is much higher than that of the larger domestic animals. To maintain this higher temperature, the oxidation in the body of relatively large quantities of heat producers must be essential. Among food heat-producers fat possesses not only the highest unit value, but is lowest in cost in proportion to value. It seems wise, therefore, in feeding fowls to introduce this nutrient into the ration as largely as is consistent with health. Beef scraps which have been carefully prepared, so that they are free from all bad odors or rancidity, and which contain a fairly large proportion of fat should be freely fed to laying fowls. They may not only with safety, but with positive advantage, be kept before such fowls all the time; and if such scraps are so fed, then corn may safely be the principal grain used.

3. The domestic fowl has little or no ability to digest fiber. Our experiments have shown that a large proportion of fiber in the ration is unfavorable to egg production, other things being equal. The practice, therefore, of using such grains as oats, barley or buckwheat largely in the rations of laying fowls would seem to be unwise. Here again it may possibly in some cases be an advantage to use these grains in small amounts occasionally, for the sake of variety. The writer, however, is not a believer in this practice. He is able to obtain exceedingly satisfactory egg product while depending almost wholly upon corn, cracked or whole, as a grain ration, in connection with a mash including bran or middlings, linseed meal, corn meal and beef scraps.

REPORT OF THE HORTICULTURAL DIVISION.

F. A. WAUGH, HORTICULTURIST; CARL S. POMEROY, ASSISTANT HORTICULTURIST; E. A. WHITE, FLORIST.

The work in horticulture has followed the same lines as in recent years. Some additional problems have been undertaken, particularly in plant breeding, but there has been no change of general policy.

The experiments in pruning and in grafting have been continued, and have been combined with rather interesting results in the production and management of dwarf fruit trees. This subject just now commands a widespread interest, and the station has been able to be of considerable assistance to suburban residents, fruit growers, nurserymen and other planters of dwarf fruit trees. It has been thought best not to put out a special bulletin on this subject for the present, though a book on dwarf fruit trees, giving the results of our experience, has been published privately.

The station work in horticulture has been greatly strengthened during the year by the addition of some new men to the staff. Mr. C. S. Pomeroy of the University of Vermont has been placed in direct charge of all experimental work, and Prof. E. A. White of Storrs Agricultural College, Connecticut, has taken charge of the work in floriculture.

Notes on the Propagation of Apples.

F. A. WAUGH.

For several years the division of horticulture has been conducting experiments on the propagation of fruit trees, especially apples. For various reasons the so-called dwarfing stocks for apples (Doucin and Paradise) have been largely employed and carefully observed. Two objects have been kept most prominently in mind in these experiments: —

1. To observe as accurately as possible the effects of stock on cion, a field of study which has long been of great interest to horticulturists.

2. To determine the practical merits of different methods of propagation, with especial reference to the production of dwarf fruit trees.

While we have had a considerable quantity of material under study, and have been able to draw fairly satisfactory conclusions of a practical nature, it has been difficult to secure proper quantities of material under suitably uniform conditions for making exact scientific comparisons. The following data, however, seem to be safe and worthy of credit.

Comparison of Standard, Doucin and Paradise Stocks.

It should be explained at this point that "standard" apple stocks are the kind almost always employed in this country. They are grown mostly in the west and south, from seeds taken from apple pomace. These seedlings are then sold to nursery men in every part of the country, and are used as stocks for budding or grafting all varieties of apples.

Doucin stocks are mostly imported from France, where they are grown, not from seeds, but from mound layers or cuttings. They are somewhat slower growers than standard stocks, and when budded with common varieties produce trees of a semi-dwarf stature.

Paradise stocks are also grown chiefly in France, and in the same manner as the Doucin stocks. They are still dwarfer in character, and when budded with ordinary varieties produce very small trees. Some of these trees bear fruit abundantly at two or three years old, and appear to be mature at a height of 8 feet, or even less.

This difference in growth may be seen in the nursery to some extent, though usually the dwarfing effect of the Doucin and Paradise stocks is less obvious there than after the trees are planted in the orchard. This reservation is especially necessary in the case of the Baldwin apple, which shows a special aptitude for the Doucin stock. Yet the general influence of the different stocks is seen in a comparison of the growth of two-year-old nursery trees given below:—

Comparison of Baldwin Trees, Two Years Old.

	On Standard.	On Doucin.	On Paradise.
Number of trees,	89	47	37
Average height (centimeters),	166	116	98
Ratio of height to diameter,	103.8	82.9	70.0

The last of these figures, ratio of height to diameter, is the most significant. A small ratio indicates what the nurseryman calls a "stocky" tree. All the figures, however, indicate that considerable differences exist between the three lots of Baldwin trees propagated in the three different kinds of stocks.

However, averages are apt to be misleading, and they never tell the whole story. More information can be conveyed if we adopt the graphic method, as in Figs. 1, 2 and 3, in which each entire group of trees is represented. Here the very different characters of the curves, as well as their differing positions in their enclosing rectangles, indicate the very striking differences in the three lots of nursery trees. The tall, narrow, smooth curve in No. 2 shows that the trees on Doucin stocks were much more uniform than on the other two. As the short, stocky trees are placed at the left of each curve with the tall, slim ones at the right, it is easily seen that the trees on Paradise were much stockier than those on Doucin, and those on Doucin were in turn shorter and stockier than those on ordinary stocks.

BALDWIN APPLE TREES. — Two years old.

Number of Individuals.

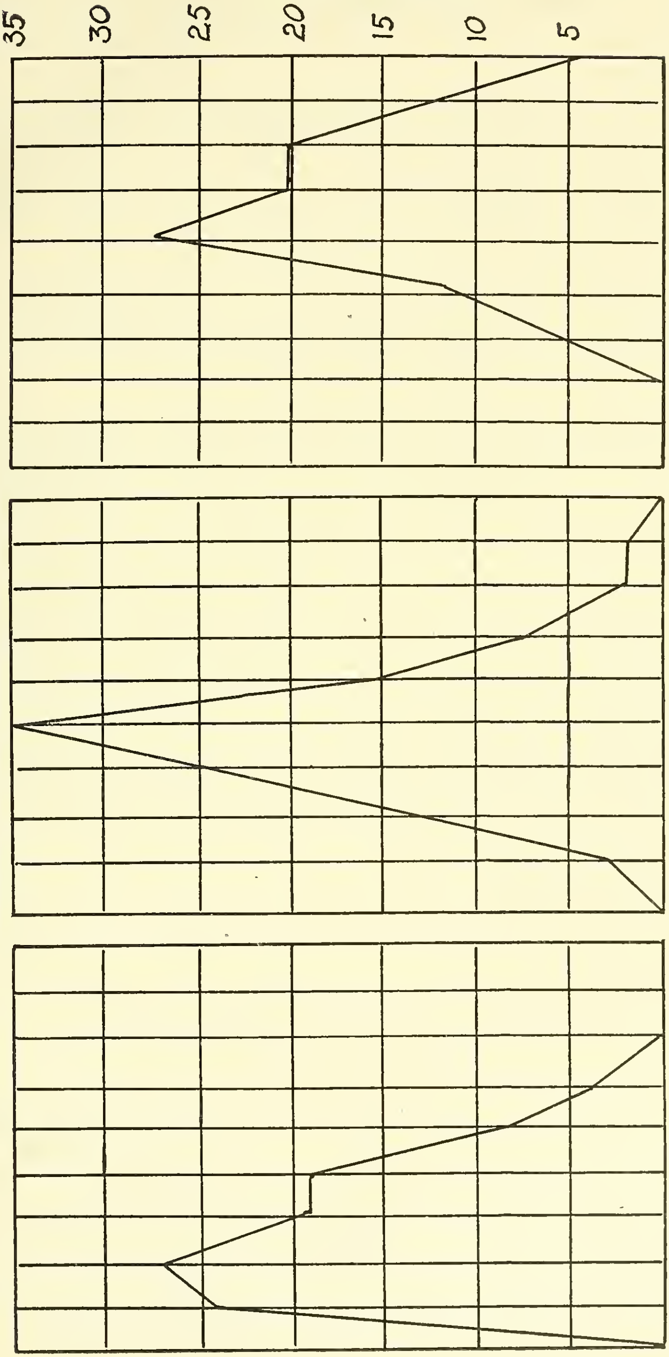

FIG. 1. — On Paradise stocks.

FIG. 2. — On Doucin stocks.

FIG. 3. — On standard stocks.

Diagrams showing the variation in Baldwin apple trees as grown on different stocks. Each curve represents the distribution of 100 trees into classes, according to the ratio of diameter to height. The smaller ratios are at the left, beginning with a ratio of 50 (height ÷ diameter = 50), progressing by 10's and ending with a ratio of 140. Horizontal lines represent numbers of individuals in each class.

These results agree with the common belief regarding the influences of the different stocks; but so far as we know these influences have never before been carefully demonstrated and measured.

The same differences are shown between trees of other varieties, such as Wealthy, McIntosh, Greening, etc., when grown on the different kinds of stocks. Unfortunately, we do not have a series of varieties growing on all three stocks, under uniform conditions and of the same age, so as to make an extended comparison. However, the following averages of two additional lots on Paradise and Doucin stocks will indicate the generally uniform character of the influence of these stocks: —

Comparison of Two-year-old Nursery Trees.

	On Doucin.	On Paradise.
Wealthy: —		
Number of trees,	84	51
Average height (centimeters),	165	128
Ratio of height to diameter,	110.0	98.5
McIntosh: —		
Number of trees,	73	50
Average height (centimeters),	148	154
Ratio of height to diameter,	106.4	96.2

Variation in Peas.

F. A. WAUGH; C. S. POMEROY.

Two new ideas, of the magnitude of great discoveries, recently brought to the front in the scientific world have developed an entirely new interest in plant breeding. This new interest has manifested itself both in practical plant-breeding work and in renewed scientific investigation. The two ideas here referred to are: (1) Mendel's law, so called; and (2) the statistical method of studying variation and heredity.

The horticultural division of the Massachusetts Agricultural Experiment Station has been engaged for several years in certain investigations in both these fields. On account of the length of time required to secure definite results, no report has yet been made of these experiments, but a brief report of some of the partial figures may be of interest at this time, particularly by way of illustrating the modern methods of study.[1]

For the purposes of this particular study, one row of peas was staked off in the middle of a field. A careful record was kept of each vine, showing its length, the number of pods borne, the length of the pods and the number of peas in each pod. The variation is shown by the following figures: —

Variation in Peas.

	Minimum.	Maximum.	Average.
Number of vines,	179	–	–
Length of vines (centimeters),	20	88	54.70
Number of pods per vine,	1	13	4.68
Length of pods (centimeters),	2	9.5	6.88
Number of peas per pod,	–	9	3.46

[1] The statistical methods of study and graphic methods of presenting data have been developed especially in England by Francis Galton and Prof. Karl Pearson. In this country the same methods have been presented by C. B. Davenport and by E. Davenport, dean of the Illinois College of Agriculture, in his recent book, "Principles of Breeding." It seems better to refer the student of plant breeding to these works, rather than to attempt a more extended explanation of these somewhat complicated methods in this report.

These figures, however, give only very meager information as to the whole range of variation, even in the qualities studied. If we wish to know the facts more accurately, we should refer to the graphic presentation on pages 172, 173 and 174.

Let us study first Fig. 1, showing the variation in length of vine. The spaces along the bottom of the figure represent different lengths of vine, in centimeters. The vertical spaces

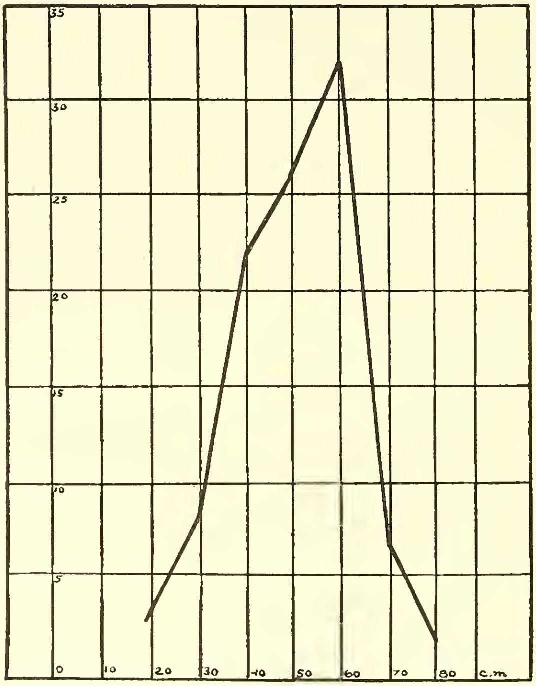

FIG. 1.

represent the number of vines of each length, the whole being represented on a percentage basis; *i.e.*, 179 vines as 100. It will be seen that in each 100 vines there were 3 having a length of 20 centimeters, 8 with a length of 30 centimeters (26–35 centimeters), 22 with a length of 40 centimeters, 32 with a length of 60 centimeters, 7 with a length of 70 centimeters and 2 with a length of 80 centimeters. The figure thus shows the composition of the entire row (the "population," as it is technically called) with respect to height.

One of the most important facts brought out by this graph

is that, while the average length of vine is 54.7 centimeters the largest number of vines have a height of 60 centimeters. This shows that the typical Excelsior pea vine in this field was nearly 10 centimeters taller than the average; or, to put the matter another way, a relatively large number of vines run below the typical height.

We may now direct our attention to the number of pods to

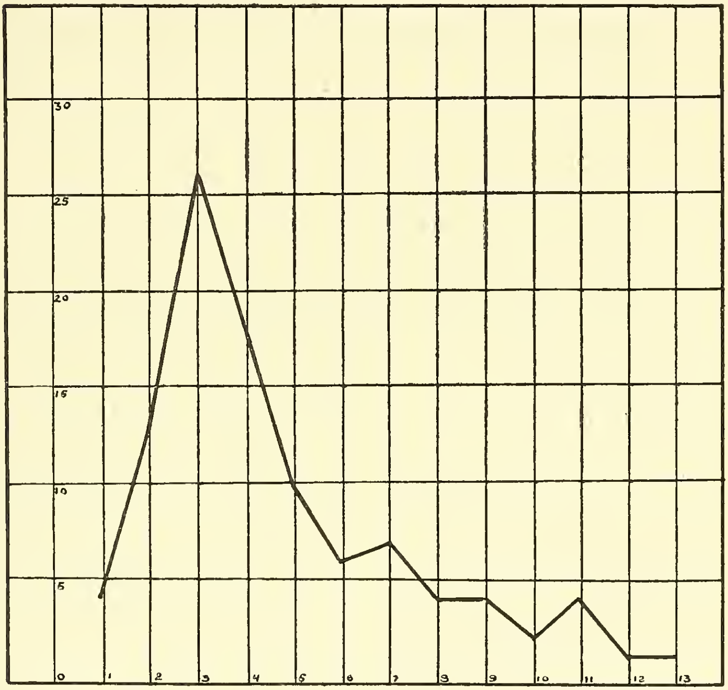

FIG. 2.

the vine. These are shown by Fig. 2. From this we see at once that the typical vine in this field (*i.e.*, the kind of vine most frequently found) contains 3 pods, while the average number is 4.68. This average is brought up by a few vines, represented at the right of the curve, bearing an unusually large number of pods.

At this point it might be suggested that the practical plant breeder, in an endeavor to improve this variety of peas, would naturally select seed from those vines bearing 8, 9, 10 or more pods.

Fig. 3 gives the curve representing the variation in number of peas, to the pod. Two pods in each 100 at the average had no peas, while one in 100 had 8 and one had 9. The average was 3.46, but the typical pod contained 4 peas, — distinctly more than the average.

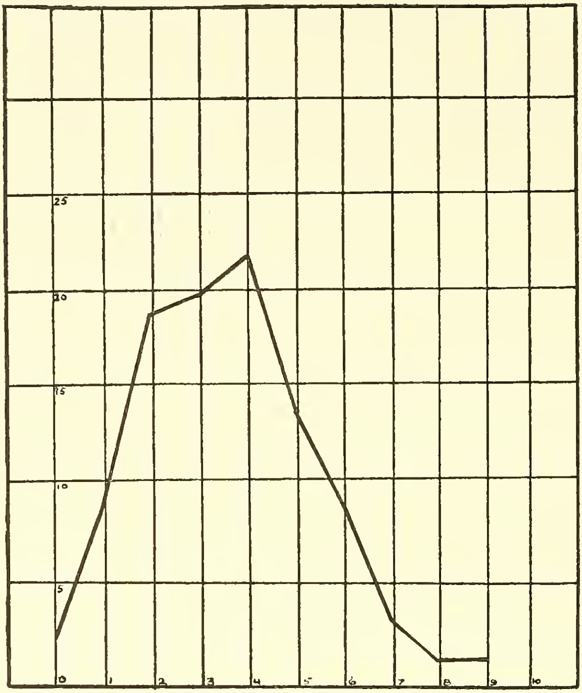

FIG. 3.

Turning once more to the requirements of the practical plant breeder, we see that he would wish to grow the largest number of peas to the pod, as well as the largest number of pods to the vine; and the question arises immediately, whether these two qualities are compatible. Do the vines bearing the largest number of pods bear also the largest number of peas to the pod? or are the pods with the largest number of peas borne on the vines having relatively few pods?

Studies in Correlation.

These questions bring us immediately to the study of correlation in variation, — one of the most important fields of plant study. In no field, moreover, is the value of the statistical method more conspicuous than in this.

There are two algebraic methods of answering the questions just asked, the first known as Yule's method,[1] and the second may be called Pearson's method [2] or the method of compound series. In applying the former method it is necessary to separate the plants into four groups, according to the two characters to be compared.

If we select those vines which bear 8 pods each or more, putting them in one class, with those bearing 7 pods or less in another class, and if we then subdivide each of these classes according to the average number of peas per pod on each vine, we shall have the following groups and figures : —

	8 Pods or More.	7 Pods or Less.
3.6 peas per pod or more, ...	9	66
3.5 peas per pod or less, ...	19	85

From which the following computation is made according to Yule's formula : —

$$\frac{(66 \times 19)-(9 \times 85)}{(66 \times 19)+(9 \times 85)}=\frac{489}{2019}=+0.242.$$

Showing a correlation of character in these groups of over 24 per cent.

Now, if the arbitrary division is made between vines bearing 7 pods or over and those bearing 6 pods or less, the rest of the computation following as before, we find the coefficient of correlation reduced to — 0.067 ; or with the division made between vines bearing 5 pods and those bearing 4, the coefficient of correlation becomes — 0.0126, showing a very little or slightly negative correlation in these groupings.

[1] See E. Davenport, "Principles of Breeding."
[2] See C. B. Davenport, p. 456, 1907, "Statistical Methods."

In plain language, it appears that the few vines bearing an abnormally large number of pods bear also an abnormally large number of peas to the pod. These would certainly be the vines which the pea grower would select in improving his stock toward greater prolificacy.

If the whole number of vines is studied in one view, without arbitrary division into classes, by the method of compound series, the correlation coefficient is found to be —0.0176,[1] a number so small as to be entirely negligible.

While the results involved are of less practical interest, it may be worth while to give the results of other correlation studies with this same material. For instance, we may study the correlation existing between the length of vine and the number of peas per vine.

Of course we would expect the taller vines to bear the largest number of pods and of peas; and, in fact, the mathematical computation shows a correlation coefficient of +0.668[2] when it is understood that a coefficient of +1.0 shows the highest correlation that can exist, and indicates two characters absolutely dependent on one another, it will be seen that +0.668 indicates very close relationship between length of vine and number of peas borne.

If we compute in a similar manner the relation existing between the number of pods per vine and the total number of peas per vine, we find a correlation coefficient of +0.897.[3]

These peas will be made the basis of further breeding experiments, and a comparison of future generations with the crop of 1907 may be expected to develop new points of interest.

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[1] Standard deviation, pods per vine, 2.64; peas per pod, 1.14.
[2] Standard deviation, length of vine, 10.5; peas per vine, 10.3.
[3] Standard deviation, pods per vine, 2.64; peas per vine, 10.3.

The Physiological Constant for the Germinating Stage of Cress.

F. A. WAUGH; C. S. POMEROY.

The subject of physiological constants was studied several years ago by the senior writer, and a report of certain investigations made, to which the reader is referred for summaries of the theories advanced by various investigators.[1] A brief statement of the present accepted belief is here given, that the subject may be properly understood by all.

A physiological constant may be defined as the amount of heat required to carry a plant through some certain stage of its growth. Thus each species of plant and each phase of development for each species would have its own physiological constant.

De Candolle,[2] writing over fifty years ago, set forth two fundamental principles which are accepted as sound to-day: "1. The active heat is the product of the degree of temperature and its duration. A more intense heat in a short time produces the same effect as a less intense heat in a longer time. This is true, provided the range of temperature and the space of time are limited. 2. Every plant requires a certain minimum of heat for each of its physiological functions, as germinating, leafing, flowering, etc. The temperatures below freezing point have no effect on plants, or at a certain low degree a destroying one; but there are many species on which the lower degrees above the freezing point have no effect. There is a starting point of vegetation for every species at a certain degree of temperature; every species requires a certain sum of heat above a certain degree of temperature, distributed over a certain space of time between a minimum and a maximum of

[1] F. A. Waugh, Vermont Agricultural Station report, II. (1898), pp. 263-272.
[2] Alphonse De Candolle, "Géographie Botanique" (1855).

duration." This minimum of temperature, which must be reached before any development takes place, has been called the critical temperature. De Candolle considered 43° as the critical temperature for all plants. Previously it had been placed at the freezing point. Now it is known that this point varies for different species and varieties, and for different functions.

The theory as above stated assumes as the constant the sum total of temperatures above a certain minimum point for the elapsed time. Such a constant is of use in places having similar climates, but obviously is not suitable for comparisons between places having different lengths of growing seasons; for plants of the same species come to maturity in northern latitudes with a very much less sum of heat than in more southern locations. In order to correct this inaccuracy, Linsser[1] proposed the aliquot idea. To determine the aliquot for any physiological function, the sum temperature for the given phase is divided by the sum temperature for the entire year, as observed at the same station. Thus, instead of depending upon the production of a certain constant *sum* of heat, certain stages are considered as due to be completed when the sum temperatures above the critical temperature equal a definite *fraction* of the sum temperature of the year. Linsser called this fraction the physiological constant.

Another question is presented by this study of the aliquot, namely: Is the critical temperature constant for a given function and species in different latitudes? No investigations are known which have sought to determine this point, but theoretically it must be answered in the negative, as a little thought will show. If we consider this constant to be the same in all latitudes, how can we conceive of certain trees and shrubs having any dormant periods in locations where the temperature rarely falls as low as that at which they bloom in our northern climate? That is, the temperature is continually above the critical temperature, and no chance is offered for the plants to rest.

Heretofore all investigations of this subject have depended upon thermometer readings for their measurements of the sum temperatures. These readings were taken two or three times a

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[1] Carl Linsser, "Die Periodische Erscheinungen des Pflanzenlebens in ihrem Verhaeltniss zu den Waermeerscheinungen." Mem. Acad. Sci., St. Petersb., sev. VII., 11 (1867), No. 7, p. 35.

day, their mean found, and that figure employed as the temperature of the day. This method has given results which were obviously very inaccurate as to the sum of heat for the time, and much more variable on some days than on others. However, in comparing different sets of observations taken in this same manner, the variations have averaged up with each other fairly well and relatively correct comparisons could be made.

For several years the division of horticulture has been carrying forward a series of investigations in this field by methods not hitherto applied to this interesting subject. The novelty and value of our methods consist in their being very much more accurate than any previously employed. Instead of depending on public meteorological reports for the computation of accumulated temperatures, we have employed the recording thermograph. This instrument makes a complete and continuous record, showing exactly the quantities of heat to which it has been exposed.

Greater accuracy was secured, secondly, by placing the thermograph in close proximity to the plants under observation. The temperatures recorded are therefore the exact temperatures to which the plants were subjected. When it is understood that previous investigators have been forced in many cases to accept meteorological records taken many miles from the plants under observation, it will be seen that this feature of our work constitutes a considerable improvement.

In the third place, much greater accuracy was secured in methods of computing sum temperatures. Having a perfect record from the thermograph, there remained only the problem of securing an exact measurement of the heat quantities thereon represented. This problem was solved by the use of the planimeter. The thermograph record appears in the form of an irregular line having a generally horizontal direction. If the height of this line, representing degrees of temperature, be measured from some base line (as, *e.g.*, the zero of the thermometer), we may readily construct a figure which offers an exact geometrical representation of the quantity of heat which we seek to measure. Such figures are shown in Fig. 1. Horizontal distances represent degrees of heat; so that the product of length by height, giving the area of the figure, gives also the quantity of accumulated heat.

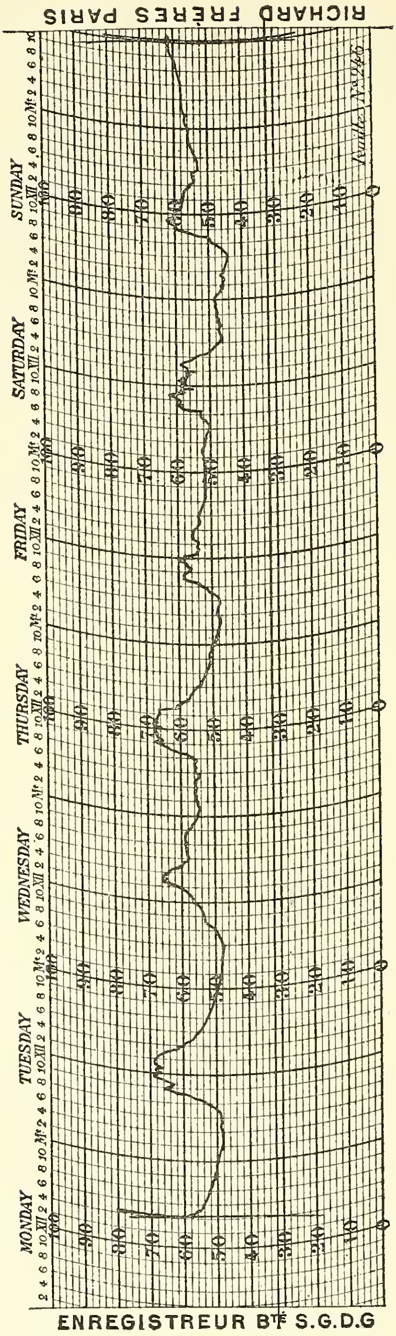
RICHARD FRÈRES PARIS
SUNDAY
SATURDAY
FRIDAY
THURSDAY
WEDNESDAY
TUESDAY
MONDAY
ENREGISTREUR B^TE S.G.D.G

FIG. 1.

In our work we have used a Coradi rolling sphere planimeter, which is one of the most reliable and accurate styles of planimeter in the market.

In seeking to apply the method here outlined to the actual determination of specific physiological constants, the first requisite was a plant which would pass through its various stages rapidly, so that a number of observations could be made in a comparatively short time; the phase in question must be one easily reproduced, and several individuals of the same age should be under observation at the same time, in order that the length of time required for the completion of the phase may be noted for a greater number. The germination stage of common curled cress was chosen for observation, as it seemed to satisfy the required conditions. Germination is rapid at ordinary temperatures, and is very uniform, and the phase can be studied at all seasons of the year, out of doors or in the greenhouse.

During the past few months 77 thermograph records have been obtained of this phase, and tabulated for study. In these records the sum temperatures above 32° have varied from 2,714 to 4,286, and the time occupied for the completion of the stage from 70 to 210 hours. The problem now, with these figures before us, is to determine at once two unknown quantities: first, the critical temperature; and second, the constant quantity of heat above that temperature required to complete the germination phase in the cress plant.

The method of making this computation will be readily

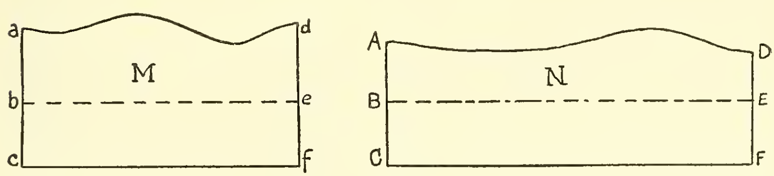

FIG. 2.

understood from the diagram (Fig. 2). The figure M represents one thermograph record for one experiment, and the figure N another record for another experiment. The lines c f and C F represent the 32° or base line. The irregular lines a d and A D represent the temperature trace. The lines b e and B E represent the critical temperature. Temperatures below

b e and B E are assumed to have no effect on the germination of the cress seeds. It is required first to determine the height of b e above c f, which height is assumed to be the same as the height of B E above C F.

According to our assumptions, the area of the figure a b e d is equal to the area of the figure A B E D. If we let the height b c = B C = x; and if we let the elapsed time in hours for figure M represented by c f = y; and let the elapsed time in hours for figure N be represented by C F = y'; then allowing m to represent the total sum temperature for the figure M = (a c f d), and n to represent the total sum temperature above zero recorded in the figure N (A C F D), we may form the following algebraic equation : —

$$m - yx = n - y'x$$

$$(y - y')x = m - n$$

$$x = \frac{m - n}{y - y'}.$$

As the quantities m, n, y and y' are all directly measurable on any two thermograph records thus compared, x may be easily computed in concrete numbers.

Some difficulty arises in the use of this formula for determining the value of x, as when any single thermograph record is compared successively with several others taken at random, decidedly irregular results follow. Values for x can be found varying all the way from $-1°$ to $+60°$; and though the majority of values lie between 5° and 10°, there is still too great variation to make the result satisfactory. This comparatively great variation is due, however, not to any essential inaccuracy in the method, but the smallness of the numbers employed.

In order to get rid of the relatively great variations shown in individual comparisons and to find a reliable average for the whole body of records, these records were plotted as shown in Fig. 3. Here each dot shows the result of a single experiment, referred to a horizontal axis for time and to a vertical axis for accumulated temperature. The distribution of these dots demonstrates at once the practically uniform character of the results.

It is now an easy matter to draw the line A B, forming the axis along which these dots cluster, and which may be assumed to be the theoretical locus of them all.

Having now this average of values shown in the line A B, we may take any time values, as 100 hours and 150 hours, and find immediately the corresponding sum temperatures, — 3,140

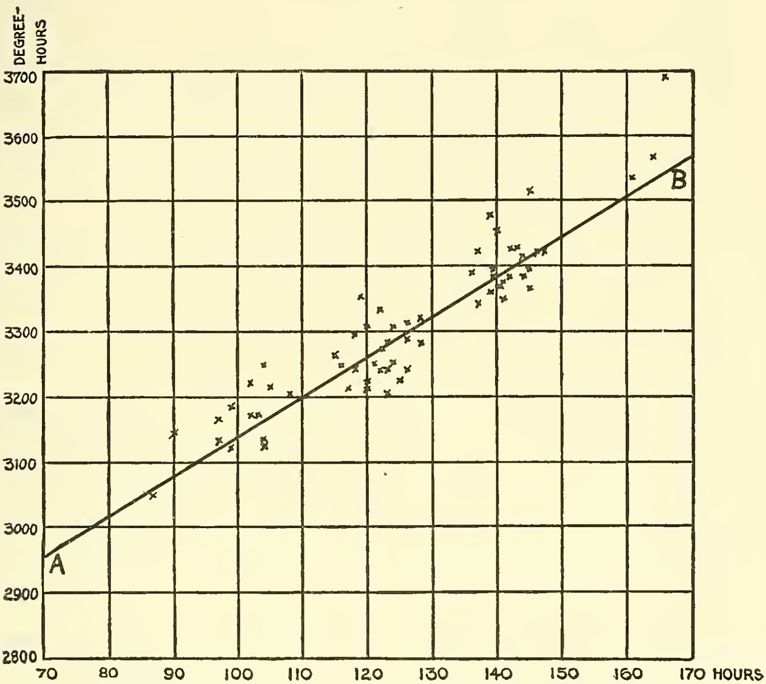

FIG. 3.

and 3,445 degree-hours. Substituting these values in the equation already formed, we find the value of x to be 6.2°. Adding this amount to 32°, the base from which we are computing, we have 38.2°, the critical temperature for the germination phase of cress.

The constant sum temperature above 38.2° required for the germination of cress should now be easily found by subtracting from each sum temperature as taken the amount of temperature intervening between 32° and 38.2°. This is secured simply by multiplying the elapsed time by 6.2°.

Applying this method to the records in hand, we find that

fairly constant results are secured, according to our expectations. The records at the extreme ends of the scale, especially at the upper end, deviate considerably from the average, but this was to have been expected, and for present purposes these records may fairly be excluded. It seems proper further to throw out three or four other records which on account of excessive deviation are open to suspicion. With these apparently abnormal records temporarily eliminated (they are to be studied further in additional experiments), we secure results which are rather remarkably uniform. Thus, the constant sum temperature being computed to be 2,530 degree-hours, the extreme deviation is less than 100, and the standard deviation is only 36.6°. The probable error is only 24.7°.[1]

Thus, the temperature being known, and lying within reasonable limits, the germination period of cress can be computed in advance within a range of approximately two hours.

The tabulated records used in these computations are appended to this report.

A few abnormal records have been reserved for further study, and there have arisen one or two intricate questions relating to the whole theory of the physiological constant which must be investigated further; but as the figures stand they seem to represent a considerable advance in this interesting field.

Tabulation of Thermograph Records.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
87,	3,054	2,516
90,	3,148	2,590
97,	3,135	2,533
97,	3,164	2,562
98,	3,126	2,518
99,	3,186	2,572
100,	3,127	2,507
102,	3,221	2,589
103,	3,173	2,535

[1] "Standard deviation" is the geometric mean of deviations. "Probable error" is defined as that departure from the mean, on either side, within which exactly one-half the variates are found.

Tabulation of Thermograph Records — Continued.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
104,	3,253	2,608
104,	3,126	2,481
105,	3,217	2,566
108,	3,205	2,536
115,	3,263	2,550
116,	3,249	2,530
117,	3,216	2,491
118,	3,245	2,513
118,	3,296	2,564
119,	3,352	2,614
120,	3,311	2,567
120,	3,214	2,470
120,	3,217	2,473
121,	3,253	2,503
122,	3,241	2,485
122,	3,336	2,570
123,	3,246	2,484
123,	3,206	2,444
123,	3,283	2,521
124,	3,309	2,541
124,	3,285	2,517
124,	3,258	2,490
125,	3,228	2,463
126,	3,290	2,509
126,	3,241	2,460
126,	3,316	2,535
128,	3,286	2,492
128,	3,310	2,516
136,	3,394	2,550
137,	3,341	2,491
137,	3,427	2,577
139,	3,479	2,617
139,	3,385	2,523
139,	3,398	2,536
139,	3,362	2,500
140,	3,376	2,508

Tabulation of Thermograph Records — Concluded.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
140,	3,451	2,583
141,	3,350	2,476
141,	3,372	2,498
142,	3,428	2,548
142,	3,381	2,501
143,	3,431	2,545
144,	3,417	2,524
144,	3,384	2,491
145,	3,397	2,538
145,	3,367	2,508
146,	3,425	2,520
147,	3,423	2,511
161,	3,536	2,538

Constant sum temperature, ... 2,530 degree-hours.
Standard deviation, ... 36.6°
Probable error, ... 24.7°

REPORT OF THE CHEMIST.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

JOSEPH B. LINDSEY.

Research division: E. B. HOLLAND and R. D. MACLAURIN.
Fertilizer division: H. D. HASKINS, E. T. LADD,[1] W. E. DICKINSON.[2]
Feed and dairy division: P. H. SMITH and L. S. WALKER.
Inspection of fertilizers, feeds and Babcock machines: W. K. HEPBURN.
In charge of feeding experiments: R. F. GASKILL.
Clerk and stenographer: HARRIET M. COBB.

PART I. — THE WORK OF THE YEAR BRIEFLY OUTLINED.

1. Correspondence.
2. Numerical summary of laboratory work.
3. Execution of the fertilizer law.
4. Miscellaneous fertilizers, soils and by-products for free analysis.
5. Execution of the feed law.
6. Milk, cream and feeds sent for free examination.
7. Execution of the dairy law.
8. Sanitary analysis of drinking water.
9. The testing of pure-bred cows.
10. Special chemical work.
11. Work completed.
12. Work in progress.

PART II. — DAIRY AND CHEMICAL STUDIES.

1. The chemical composition of milk.
2. The effect of food on the composition of milk and butter fat, and on the consistency or body of butter.
3. Standard for Babcock glassware.

[1] Resigned Jan. 1, 1908. [2] Resigned Dec. 1, 1907.

Part I. — The Year's Work briefly outlined.

J. B. LINDSEY.

On July 1, the division of foods and feeding and the fertilizer division were united, and termed the department of plant and animal chemistry.

A new division was created, to be known as the research division. This latter division will devote itself to the study of problems in animal nutrition and investigations in plant and animal chemistry.

The fertilizer division takes charge of the annual inspection of commercial fertilizers, examines samples of fertilizers, refuse manurial substances and soils sent to the station, and will devote the remainder of its time to other problems either of a control or research nature.

The feed and dairy division has charge of the execution of the feed and dairy laws, examines samples of water, supervises the testing of pure-bred cows, analyzes samples of feed stuffs and dairy products connected with experiments in progress at the station as well as those sent in for examination.

A brief outline of the work follows, and includes that of the two separate divisions *previous* to the reorganization.

1. Correspondence.

The enactment of an amendment to the fertilizer law, requiring the publication of station valuations, the local dealer's retail cash price and the percentage difference between the two, has noticeably increased the correspondence during the past year. In addition to the above, a large number of letters has been received and answered relative to problems connected with fertilizers, feed stuffs and dairying. Numerous analyses of fertilizers, feed stuffs, dairy products and water have been

reported directly to the manufacturers, local agents and private persons. The estimated number of letters of all kinds sent out from Dec. 15, 1906, to Dec. 1, 1907, — eleven and one-half months, — approximated 5,395.

2. Numerical Summary of Laboratory Work.

From Dec. 15, 1906, to Dec. 1, 1907, there have been received and examined 99 samples of water, 529 of milk, 1,732 of cream, 135 of feed stuffs, 176 of fertilizers and fertilizer materials, 48 soils and 21 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 338 samples of milk, 40 samples of cream, 52 samples of butter, 68 samples of butter oil, 111 samples of cattle feeds, 336 samples of agricultural plants, 31 samples of soils and 32 samples of fertilizers. There have also been collected and examined 841 samples of cattle feeds in accordance with the requirements of the feed law, and 513 samples of fertilizer in accordance with the fertilizer law. The total for the year has been 5,102.

In addition to the above, twenty-one candidates have been examined and given certificates to operate Babcock machines, and 3,082 pieces of Babcock glassware have been tested for accuracy of graduation, of which 204, or 6.62 per cent., were inaccurate.

3. Execution of the Fertilizer Law (Acts of 1896, Chapter 297, and 1907, Chapter 289).

Since July 1, Mr. H. D. Haskins has assumed charge of this work, and has carried it forward with energy and perseverance. Mr. Haskins submits the following report: —

A new fertilizer act, passed by the State Legislature and approved April 11, 1907, reads: —

Be it enacted, etc., as follows:

Section 1. The bulletins or other publications of the Massachusetts agricultural experiment station containing information about fertilizers shall, in all cases, state the dealers' cash price per ton for such fertilizers, the value per ton of the ingredients of the same, and the percentage of difference between the said price and the said value.

Section 2. This act shall take effect upon its passage.

In compliance with the above act, the necessary data have been collected, and fertilizer Bulletin No. 119 gives, in detail, the required information as well as the method employed in obtaining the same.

During the season 513 samples, representing 358 distinct brands, have been analyzed and the results have been published. (See Bulletin No. 119, December, 1907.) Forty-five more licensed brands were analyzed than during the previous year. Seventy-seven manufacturers, importers and dealers have secured licenses for 317 distinct brands of fertilizer during 1907.

Samples were taken in about 80 different towns and cities in the State. Of the 358 brands analyzed, 275 were complete fertilizers; 38 were materials furnishing nitrogen and phosphoric acid, such as ground bone, tankage and dry ground fish; 14 were potash compounds; 9 were phosphoric acid compounds; 15 were compounds furnishing nitrogen; and 7 were compounds furnishing potash and phosphoric acid.

Trade Values of Fertilizing Ingredients for 1907.

	Cents per Pound.
Nitrogen: —	
In ammonia salts,	17½
In nitrates,	18½
Organic in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers,	20½
Organic nitrogen in fine bone and tankage,	20½
Organic nitrogen in coarse bone and tankage,	15
Phosphoric acid: —	
Soluble in water,	5
Soluble in ammonium citrate (reverted),	4½
In fine bone and tankage,	4
In coarse bone and tankage,	3
In cotton-seed meal, linseed meal, castor pomace and wood ashes,	4
Insoluble (in neutral citrate of ammonia in mixed fertilizers),	2
Potash: —	
As sulfate, free from chloride,	5
As muriate (chloride),	4¼
As carbonate,	8

The above prices were made up from quotations obtained for the six months preceding March 1, 1907, and actually show the price at which the various ingredients were retailed in markets

at centers of distribution in New England, New York and New Jersey.

The average comparative commercial value of the 275 brands of complete fertilizer analyzed was $24.19, the average retail cash price $35.40 and the percentage of difference 44.85.

Of the 275 brands, 113, or about 41 per cent., failed to meet the manufacturers' guaranty in some one or more of the essential elements; many of these deficiencies were made up by an excess of some one or more of the other essential ingredients. Twenty-one of the samples of complete fertilizers, however, showed a commercial shortage ranging from 79 cents to $13.50 per ton.

Eighty-six brands were deficient in one, 23 in two and 4 in all three of the essential elements of plant food. Seventy were deficient in nitrogen, 43 in potash and 28 in phosphoric acid.

Among the 38 brands of ground bone, tankage and dry ground fish, 16 failed to meet the guaranty in nitrogen and 4 in phosphoric acid; only a few of these brands, however, show a commercial shortage. The average retail cash prices, valuations and percentages of difference of the ground bones, dissolved bones, tankages and dry ground fish were as follows: —

	Retail Cash Price.	Valuation.	Percentage Difference.
Ground bone,	$29 46	$27 45	7.32
Dissolved bone,	25 50	25 03	1.88
Tankage,	21 67	29 93	27.60 [1]
Dry ground fish,	39 00	39 89	2.23 [1]

[1] Valuation in excess of selling price.

In case of chemicals and other raw materials, it may be said that 2 samples of nitrate of soda, one sample of dried blood and 5 samples of cotton-seed meal failed to meet the nitrogen guaranty. Two samples of muriate of potash and one sample of carbonate of potash did not meet the potash guaranty. One sample of superphosphate, 1 sample of dissolved bone black and 2 samples of dissolved phosphates and potash fell below the phosphoric acid guaranty.

Cost of One Pound of Nitrogen, Phosphoric Acid and Potash in Raw Materials.

	Cents.
Nitrogen: —	
From nitrate of soda,	19¼
From dried blood,	22½
From cotton-seed meal,	23⅗
From linseed meal,	24⅖
From castor pomace,	23¼
Potash: —	
From carbonate of potash,	8
From sulfate of potash,	5⅖
From muriate of potash,	4½
Available phosphoric acid: —	
From dissolved bone black,	7½
From acid phosphate,	5⅘

A pound of total phosphoric acid in "Thomas slag phosphate" has cost the consumer on the average about 5 cents.

Summary of Analyses of Complete Fertilizers, 1907.

The table below shows the comparative quality of the brands of complete fertilizer analyzed during the year, and gives the following information concerning each manufacturer: (*a*) the number of brands of complete fertilizer collected and analyzed; (*b*) the number of brands in which all three of the essential ingredients of plant food are equal to the lowest guaranty; (*c*) the number which do not show a commercial shortage, including those fertilizers where a deficiency of any one element is offset commercially by an excess of some of the other essential ingredients; (*d*) the per cent. of the whole number of complete fertilizers sold by each company not having a commercial shortage. The last three columns indicate the number of brands deficient in one, two and in all three of the essential elements of plant food.

TABLE I.

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
W. H. Abbott,	3	1	3	100.00	2	-	-
American Agricultural Chemical Company.	61	45	58	95.08	14	2	-
Armour Fertilizer Works,	10	8	10	100.00	1	1	-
Beach Soap Company,	3	1	2	66.66	2	-	-
Berkshire Fertilizer Company,	4	2	4	100.00	2	-	-
Bonora Chemical Company,	1	-	1	100.00	1	-	-
Bowker Fertilizer Company,	33	19	29	90.00	8	6	-
J. Breck & Son,	4	1	1	25.00	3	-	-
Buffalo Fertilizer Company,	4	-	1	25.00	3	1	-
Coe-Mortimer Company,	7	2	3	42.85	4	1	-
Eastern Chemical Company,	1	-	1	100.00	1	-	-
Eureka Liquid Fertilizer Company,	1	-	-	-	-	-	1
R. & J. Farquhar & Co.,	5	4	4	80.00	-	1	-
Fertilizer Products Company,	1	1	1	100.00	-	-	-
C. W. Hastings,	1	-	-	-	1	-	-
Lister's Agricultural Chemical Works,	7	5	6	85.71	2	-	-
Mapes Formula & Peruvian Guano Company.	16	12	16	100.00	4	-	-
Mitchell Fertilizer Company,	1	-	1	100.00	1	-	-
National Fertilizer Company,	15	8	13	86.66	5	2	-
New England Fertilizer Company,	7	4	6	85.71	2	1	-
Olds & Whipple,	4	3	4	100.00	1	-	-
Parmenter & Polsey,	2	2	2	100.00	-	-	-
R. T. Prentiss,	3	-	-	-	-	1	2
Benjamin Randall,	2	1	2	100.00	-	1	-
W. W. Rawson & Co.,	3	3	3	100.00	-	-	-
Rogers & Hubbard,	8	4	8	100.00	4	-	-
Rogers Manufacturing Company,	8	5	7	87.50	3	-	-
Ross Brothers,	1	-	1	100.00	1	-	-
N. Roy & Son,	1	-	-	-	1	-	-
Russia Cement Company,	11	7	11	100.00	4	-	-
Sanderson Fertilizer Company,	4	1	1	25.00	2	1	-
M. L. Shoemaker,	1	1	1	100.00	-	-	-
Smith Agricultural Chemical Company.	8	1	4	50.00	4	2	1
Sterling Chemical Company,	1	-	1	100.00	-	1	-

TABLE I — *Concluded.*

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
Swift's Lowell Fertilizer Company,	14	3	12	85.71	10	1	-
Tavender Process Company,	1	1	1	100.00	-	-	-
Whitman & Pratt,	4	3	4	100.00	1	-	-
Wilcox Fertilizer Works,	6	6	6	100.00	-	-	-
A. H. Wood & Co.,	1	1	1	100.00	-	-	-

Summary of Analyses of Ground Bone, Dissolved Bone, Tankage and Dry Ground Fish, 1907.

The following table presents the same information as the previous one, with the exception of the column giving the percentage number which do not show a commercial shortage; this was omitted on account of the small number of brands of these raw materials licensed by each manufacturer.

TABLE II.

MANUFACTURER.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
W. H. Abbott,	1	1	1	-	-
American Agricultural Chemical Company,	1	-	-	1	-
Armour Fertilizer Works,	1	1	1	-	-
Beach Soap Company,	1	-	1	1	-
Bowker Fertilizer Company,	4	2	4	2	-
Buffalo Fertilizer Company,	1	-	-	-	1
John C. Dow & Co.,	1	1	1	-	-
R. & J. Farquhar & Co.,	1	-	1	1	-
Thomas Hersom & Co.,	2	2	2	-	-
Home Soap Company,	1	1	1	-	-
Geo. E. Marsh Company,	1	-	1	1	-
D. M. Moulton,	1	-	-	-	1

TABLE II — *Concluded.*

Manufacturer.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
National Fertilizer Company,	2	–	1	2	–
Olds & Whipple,	1	1	1	–	–
Parmenter & Polsey Fertilizer Company,	1	–	1	1	–
W. W. Rawson & Co.,	1	1	1	–	–
Rogers & Hubbard Company,	2	1	2	1	–
Rogers Manufacturing Company,	1	1	1	–	–
Russia Cement Company,	1	1	1	–	–
Sanderson Fertilizer and Chemical Company,	1	–	–	1	–
Springfield Rendering Company,	2	1	2	1	–
Swift's Lowell Fertilizer Company,	4	2	3	2	–
T. L. Stetson,	1	–	1	1	–
A. L. Warren,	1	1	1	–	–
Whitman & Pratt Rendering Company,	1	–	1	1	–
Wilcox Fertilizer Works,	1	1	1	–	–
Sanford Winter & Son,	1	1	1	–	–
J. M. Woodard & Bro.,	1	1	1	–	–

4. Miscellaneous Fertilizers, Soils and By-products for Free Analysis.

During the past season 208 samples of fertilizer and refuse by-products used for fertilizing purposes, 79 soils and 25 miscellaneous substances have been fowarded for analysis by farmers and others interested in agriculture. The greater part of these samples have been taken according to printed instructions forwarded from this office. It is the usual custom, when application is made for free analysis, to send the applicant the necessary directions for taking an average sample. This is of the utmost importance, for unless an average sample is furnished, a representative analysis cannot be obtained. As a general thing, these samples are analyzed in the order of their arrival. During the season of the inspection of commercial fertilizers we are not able at all times to promptly attend to the requests for the analysis of this class of materials. Samples

are, however, tested as promptly as possible, and reported together with whatever information has been asked for by the applicant. Samples received during the fall and winter months can be examined more quickly, and will ordinarily be reported in a few days after they are received.

5. Execution of the Feed Law (Acts of 1903, Chapter 122).

Since July 1, Mr. P. H. Smith has been charged with carrying out the provisions of this act, and has proved his ability to handle the work to the complete satisfaction of the writer. At the beginning of the year 1907 the inspector made a complete canvass of the State, and collected 477 samples, all of which were examined during the winter and early spring months. It was not possible to publish the results in bulletin form, but the analyses of those falling substantially below the guaranty, or in which any inferior condition was noted, were reported to the manufacturer, with such comments and suggestions as the circumstances seemed to warrant.

The chief result of the inspection was the discovery of numerous lots of inferior cotton-seed meal. Because of heavy rainfalls in the autumn of 1906, large quantities of cotton-seed were considerably damaged, and as a result much of the meal was seriously off grade in color, texture and chemical composition. Of the 75 samples examined, 65 were guarantied to contain 41 or more per cent. protein; and of this number 75 per cent. fell below the guaranty, some very much more so than others. Those samples put out by Kaiser & Brown, Memphis, Tenn., bore a 41 per cent. guaranty and tested 20 to 21.50 per cent. of protein, and were unquestionably fraudulent. Of the 18 lots of Star Brand put out by the J. Lindsey Wells Company, Memphis, Tenn., only 3 met their guaranties; 8 fell nearly 5 per cent. of protein below the minimum, and 7 showed a deficit of 5 to 7 per cent.

While it was naturally beyond the power of man to control the weather conditions, it is believed that many southern brokers were decidedly lax in their method of dealing, and attached a 41 per cent. protein guaranty to whatever meal they shipped, without any particular regard to its quality.

The writer is also convinced that certain northern jobbers soon discovered that the meal they were receiving was inferior to the guarantied representations. They proposed, however, to take their chances, and, in case they were found out, plead ignorance and bad weather; and, if absolutely necessary, settle with the local dealer with the least loss to themselves. The station, by all means in its power, endeavored to keep both the dealer and consumer informed regarding the true conditions. A special circular of 8 pages was prepared and sent to every important feed dealer in the State. All samples of meal received from local dealers and private parties were examined and the results reported within two or three days.

Beginning in late August, 1907, the inspector canvassed the State, and completed his work about the middle of October, collecting 364 samples, all of which have been examined chemically and many also submitted to a microscopic analysis. Concentrated feeds have ruled exceptionally high in price, and many dealers were carrying very limited stocks, some of the ordinary brands being temporarily out of the market. Comparatively few violations of the law were noted, and these were mostly of a technical character. The results of the autumn inspection are now in press (December, 1907), and will appear in bulletin form.

Only one new feed was found during the present autumn. It is known as flax feed, and is composed substantially of one-third small and imperfectly developed flax seed and two-thirds of a variety of ground weed seeds. It has an extremely bitter taste. It has been fed to several cows in the station herd, and no objectionable taint was noted in the milk. The cows ate it rather grudgingly when fed by itself, but consumed it readily when mixed with other grains. The price asked — $26 a ton — is considered high.

6. Milk, Cream and Feeds sent for Free Examination.

Many dairymen frequently send samples of milk and cream to be tested for total solids and fat, in order to ascertain the quality of the product yielded by the cows composing their herds. The State and local boards of health, as well as the large milk contractors, keep a watchful eye over the composi-

tion and condition of the milk supply of the State, and many producers frequently receive warning that their product is deficient in one or more particulars. This induces them to send samples to the station for examination and to ask for advice. The milk is examined promptly, and the results, together with the necessary comments, are forwarded without delay. The station is always ready, to the full extent of its resources, to lend a helping hand to such as ask. One creamery sends all of its samples to the station to be tested for butter fat, and two others send a number of samples every two weeks. A charge is made in such cases, to cover the necessary expense.

Samples of feeds are constantly received from farmers, local dealers and jobbers, who wish to ascertain not only if the materials sent are as represented, but also regarding their particular feeding value. In most cases a partial chemical or microscopic analysis only is necessary to enable one to furnish the desired information. There is a constant tendency on the part of some jobbers to use the station in place of private chemists. It must be distinctly understood that, while it is the aim of the station to furnish all parties with whatever special information its equipment makes possible, its laboratory cannot be continually at the call of those engaged in private business operations.

7. Execution of the Dairy Law (Acts of 1901, Chapter 202).

This law requires the station (*a*) to test, for accuracy of graduation, all glassware used in connection with the Babcock test or any other test in determining the value of milk and cream; (*b*) to examine for competency all parties operating such tests; and (*c*) to inspect yearly all machines thus used. The station is given authority to collect, from the parties for whom the work is done, sufficient money to cover the actual expense involved.

It is believed that the law could be improved by the addition of an amendment providing a small yearly appropriation ($400), to enable the station to make semiannual inspections of machines and operators, and by giving it authority to remove all operators who employed dirty glassware and who were not

conscientiously performing their duties. The result of the year's work may be summarized as follows: —

(*a*) *Testing of Glassware.* — Each piece of glassware found to be correct has the words "Mass. Ex. Sta." etched on. There were examined 3,082 pieces, of which 204, or 6.62 per cent., were condemned.

(*b*) *Examination of Candidates.* — Twenty-one candidates were examined during the year 1907. Most of those presenting themselves for examination had a fair understanding of the process, although it was frequently necessary to refuse certificates, insist on further preparation and a second examination. It is believed that the station would be false to its trust if it allowed candidates to pass who did not have a satisfactory theoretical and practical understanding of the method of procedure.

(*c*) *Inspection of Babcock Machines.* — The annual inspection of Babcock machines was made in November of 1907. Of the 36 places visited, 22 were creameries, 11 milk depots, 2 city milk inspectors and 1 a chemical laboratory. Sixteen of the creameries were co-operative and 5 were proprietary or managed by stock companies. The 11 milk depots in operation were in every case proprietary.

Thirty-seven machines were inspected, of which 2 were condemned and 1 was found needing additional heat. The machines in use are 14 Facile, 9 Agos, 6 Wizard, 5 Electrical and 2 Stoddard.

The glassware as a whole was clean, but a few still use very dirty bottles and 3 were found using untested glassware. Following is a list of creameries and milk depots now in operation that pay by the Babcock test: —

1. Creameries.

Location.	Name.	President or Manager.
1. Ashfield, ...	Ashfield Co-operative, . .	Wm. Hunter, manager.
2. Belchertown, . . .	Belchertown Co-operative, .	M. G. Ward, president.
3. Brimfield, . . .	F. N. Lawrence, . . .	F. N. Lawrence, proprietor.
4. Cheshire, ...	Greylock Co-operative, .	C. J. Fales, president.
5. Cummington, . . .	Cummington Co-operative, .	W. E. Partridge, manager.

1. *Creameries* — Concluded.

Location.	Name.	President or Manager.
6. Egremont,	Co-operative,	E. A. Tyrrell, manager.
7. Easthampton,	Hampton Co-operative,	W. H. Wright, superintendent.
8. Heath,	Cold Spring,	F. E. Stetson, manager.
9. Hinsdale,	Hinsdale Creamery Company.	W. C. Solomon, proprietor.
10. Lenox,	Lenox Creamery,	P. A. Agnew, manager.
11. New Salem,	New Salem Co-operative,	W. A. Moore, president.
12. Monterey,	Berkshire Co-operative,	F. A. Campbell, manager.
13. North Orange,	North Orange Co-operative,	C. E. Dunbar, manager.
14. Northfield,	Northfield Co-operative,	L. R. Smith, superintendent.
15. Shelburne,	Shelburne Co-operative Creamery.	Ira Barnard, manager.
16. Shelburne Falls,	Shelburne Falls Creamery,	T. M. Totman, proprietor.
17. Springfield,	Tait Bros.,	Tait Bros., proprietors.
18. Westfield, P. O. Wyben Springs.	Wyben Springs Co-operative,	C. H. Wolcott, manager.
19. West Newbury,	West Newbury Co-operative,	R. S. Brown, manager.
20. Williamsburg,	Williamsburg Creamery,	D. T. Clark, manager.
21. Worthington, P. O. Ringville.	Worthington Co-operative,	M. R. Bates, superintendent.

2. *Milk Depots.*

Location.	Name.	President or Manager.
1. Cambridge,	C. Brigham Company,	J. R. Blair, manager.
2. Cheshire,	Ormsby Farms,	E. B. Penniman, proprietor.
3. Beverly,	Cherry Hill Farm,	Henry Fielden, superintendent.
4. Dorchester,	Elm Farm Milk Company,	J. H. Knapp, manager.
5. Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
6. Southboro,	Deerfoot Farm,	S. H. Howes, manager.
7. Boston, P. O. Charlestown.	D. W. Whiting & Sons,	George Whiting, manager.
8. Boston, P. O. Charlestown.	H. P. Hood & Sons,	Wm. Brown, manager.
9. Boston,	Boston Dairy Company,	W. A. Graustein, president.
10. Boston,	Walker-Gordon Laboratory,	Merrill B. Small, manager.
11. Boston, P. O. Roxbury,	Alden Bros.,	Alden Bros., proprietors.

8. Sanitary Analysis of Drinking Water.

The experiment station has made sanitary examinations of drinking water since its establishment in 1882. Since January, 1903, because of the abuse of the privilege of free analysis

and because of the increase of other important lines of work, a charge of $3 a sample has been made. Special jars are furnished, together with full instructions for collecting and forwarding the samples. An analysis of water sent in shipper's jar will not be made, neither will bacteriological nor mineral analyses be undertaken. A sanitary analysis is made to determine whether the water is contaminated with bad drainage from privy vaults, barns or sinks. A mineral analysis is usually undertaken to ascertain the amount of the several mineral ingredients contained in the water, and thus to gain information relative to its supposed medicinal properties. Parties wishing such information are referred to private chemists.

The water examined the past year was of the usual quality. It was derived largely from springs and wells which had frequently become polluted from the ordinary sources. After the soil once becomes contaminated, it requires considerable time to purify itself, and the water is likely to be rendered unfit for use for a number of years. Too great care cannot be exercised by parties depending for their supply upon wells and springs located close to dwelling houses, barns or other buildings. Samples are sometimes found contaminated with lead. It is strongly advised that all lead pipe be removed and replaced with iron coated with asphaltum or with galvanized-iron pipe. Lead is a poison, and if it once enters the system it is very difficult to eradicate it.

9. The Testing of Pure-bred Cows.

This department continues its work in testing pure-bred cows under the rules and regulations of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeders' associations. The work for Jersey and Guernsey breeders is confined almost exclusively to consecutive monthly tests for the purpose of securing yearly records. Sixty-three cows are now in the test, which requires the services of one man nearly the entire month. Holstein breeders require, as a rule, seven-day tests, although in some cases the time limit is set at fourteen and thirty days, and in occasional instances ninety days, should the animals under test be making phenomenal records. At times between the months of December and May four or five men are thus employed.

Only one Ayrshire breeder (G. E. Stone of Littleton) is at present making a yearly test of his herd.

The station has issued a special circular, giving breeders full information relative to the making of such tests; the circular also states the rules and regulations governing the same. All records, after being verified and sworn to, are forwarded to the several cattle clubs and a duplicate copy kept on file at this office. There have been completed during the year 5 Guernsey and 30 Jersey yearly records and 70 Holstein records (53 of which were of seven days' duration, 10 for fourteen days and 7 in excess of fourteen days).

It hardly seems that it is the proper function of the experiment station to do work of this kind, but it will continue to give such matters attention until other facilities are provided for the accommodation of breeders.

10. Special Chemical Work.

The station has co-operated with the association of official agricultural chemists in studying the accuracy of methods for the determination of nitrogen and in ascertaining the most suitable methods to be used in the analysis of condensed milk. These results were reported to several referees of the association.

Mention may also be made of a study to ascertain the best methods to be employed in determining water and the several sugars in molasses, also of a determination of the fat constants of soy bean oil. These investigations will be published as a part of this report or elsewhere.

11. Work Completed.

Molasses and Molasses Feeds.

The station has made a study of the value of molasses and molasses feeds for dairy cattle, horses and swine, and has published its findings, together with the most important results secured by German and French investigators, in Bulletin No. 118, which is now ready for distribution.

The value of molasses was discussed under the following headings: composition, effect of molasses on digestibility of other feed stuffs, digestion coefficients for molasses, relative values of molasses and corn meal, and the uses of molasses as

a component of the daily rations for the several important kinds of farm animals. The conclusions may be summarized briefly as follows: —

For Dairy Cattle. — No particular advantage is to be gained under ordinary conditions by the northern farmers, from the use of molasses as a food in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition, to induce a temporary maximum food consumption and for facilitating the disposal of unpalatable and inferior roughage and grain, two to three pounds daily of molasses undoubtedly would prove helpful and economical.

For fattening Cattle. — Some three pounds daily may be fed advantageously, especially during the finishing process, when the appetite is likely to prove fickle. The object at such times should be to make the food especially palatable, and thus induce a maximum consumption and also to secure a bright, sleek appearance.

For Horses. — In spite of the many reports favorable to the use of molasses for horses, the writer is not inclined to recommend to northern farmers its indiscriminate use in place of the cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive and for improving the palatability of rations, two to three pounds daily of molasses would undoubtedly prove productive of satisfactory results.

For Pigs. — These animals will consume reasonably large quantities of cane molasses daily without ill effects (one pound per one hundred pounds live weight). Small amounts (two to three ounces daily) must be given at first and gradually increased. Molasses must be fed with foods reasonably rich in protein. If skim milk is not available, a combination by weight of two parts bran, one part gluten feed, one part corn meal and one part molasses, or one part tankage, four parts corn meal and one part molasses, ought to prove satisfactory. It is believed that no particular advantage is to be gained by employing molasses for pig feeding other than an appetizer.

The residuum molasses from Porto Rico (blackstrap) is brought in tank steamers and offered in Boston at 14 cents a gallon of 12 pounds in barrel lots. It contains about 1,100

pounds of digestible organic matter in one ton, and as a food has about 75 per cent. of the value of corn meal. The particularly favorable effect of molasses as an appetizer, etc., naturally is not included in the above estimate of its worth; neither does its lack of protein as compared with corn meal nor the extra cost and bother of handling enter into the calculation.

The value of molasses feeds was summarized under composition, digestibility, for milk production and as compared with home-mixed grain rations.

It was shown that these feeds were composed of oat and barley residues, partly ground grain screenings and malt sprouts in many cases, one-fourth to one-third molasses, and sufficient gluten feed and cotton-seed meal to supply the protein guarantied.

The total digestible organic nutrients contained in molasses feeds are in excess of those contained in wheat bran, but noticeably below those contained in flour middlings and gluten feed. The amount of protein contained in bran, middlings and gluten feed is decidedly greater than in the average of the several molasses feeds. The latter class of feeds may be said to be only moderately digestible.

No advantage is to be gained from feeding molasses feeds in place of home mixtures of standard concentrates. Digestible protein in the former feeds is decidedly more expensive, and digestible matter can generally be purchased for less money in the home mixtures.

The fact that many of the prepared molasses feeds contain considerable quantities of unground weed seeds is a decided argument against their use. Weed seeds pass through the animal undigested, and are distributed with the manure and greatly increase the cost of subsequent cultivation.

The Digestibility of Proprietary Cattle Feeds.

A considerable number of mixtures of various by-products are offered as ready rations for dairy stock. Among these may be mentioned Buffalo creamery feed, Chapin's alfalfa meal, Biles union grains, H. O. and Quaker dairy feeds, Protena, Schumacher's stock feed, Sucrene, Green Diamond and Holstein sugar feeds. In addition to an analysis, the *degree of*

digestibility is quite necessary in order to form an accurate opinion of the true nutritive value of a feed stuff. The station has tested the digestibility of all of the above-mentioned feeds, and intends publishing the detailed results.

The requirements of any ready ration, either mixed at home from standard by-products, or purchased in the form of a proprietary mixture, may be briefly stated as follows: —

1. It should be bulky, palatable, and free from mold and rancidity.

2. It should contain at least 16 pounds of digestible protein in 100.

3. It should contain substantially 70 pounds of digestible organic nutrients in 100, and not over 9 per cent. of total fiber.

The results of our observations and digestion studies have shown that only one proprietary feed — Biles union grains — substantially conformed to the above requirements. This feed contained 17.8 pounds of digestible protein, 66.7 pounds of digestible organic matter and 9.6 pounds of total fiber in 100 pounds. The other feeds showed from 7.5 to 16.1 pounds of digestible protein, from 52 to 62 pounds of digestible organic matter and from 10 to 18 pounds of total fiber in 100. Most of the above feeds are quite expensive as sources of digestible protein, and furnish digestible organic matter at a higher cost than it can be had in the ordinary standard by-products.

The Effect of Soy Beans minus the Oil, and of Soy Bean Oil on the Composition of Milk and Butter Fat, and on the Consistency or Body of Butter.

An experiment was in progress during the winter of 1906-07 to study the physiological effect of this legume upon milk and butter. The experiment is one of a series planned to ascertain the feeding effect of the various groups of substances — protein, carbohydrates and fat — upon milk secretion in general. The beans were shipped to a western oil mill to secure the removal of the oil, the percentage being reduced from 16 to 8. It was hoped that after the extraction the residue would not show over 3 per cent., but this result was not secured. It is intended to publish and discuss the experiment in detail at a

future time. The most important results only are now mentioned: —

1. Soy bean meal, after the extraction of oil, had no effect in changing the relative proportions of the several milk ingredients, did not noticeably modify the chemical composition of the butter fat, and exerted no marked influence on the body of the butter.

2. Soy bean oil temporarily increased the percentage of fat in the milk, modified the composition of the butter fat by decreasing the saponification number, the percentage of soluble fatty acids and the percentage of volatile fatty acids; it increased the iodine number from 32 to 40, and hence the olein percentage, but did not change the melting point of the fat. The oil likewise produced a softer, more yielding butter, that would not stand up well at 70° F. and above.

12. Work in Progress.

Studies in Milk Secretion.

Two grade Holstein cows are being fed a continuous hay diet during an entire lactation period; two similar cows a hay and moderate grain diet during an entire period of lactation; two Jersey cows — a high grade and a pure bred — are also receiving a hay and moderate grain diet during a period of lactation.

The objects sought are: (*a*) the variations in the chemical composition of the milk and milk fat; (*b*) the milk fat constants; (*c*) the comparative composition of the milk fat from Holstein and Jersey cows under similar conditions of feed and care. It is also intended to observe, so far as possible, the general character of the butter resulting from the hay and from the hay and grain diet. This work will continue until the autumn of 1907.

Studies in Soil Analysis.

Samples of soils from Field A, which is divided into eleven different plots, and which has been under continuous treatment since 1889, are being submitted to a careful examination, to ascertain the chemical variations in the soil resulting from different methods of fertilization. The results thus far secured

show very slight differences in the amount of the several constituents present. This work is a part of an experiment under the management of the agricultural department of the station.

Effect of Molasses on Digestibility.

It is a well-known fact that the addition of considerable quantities of starch, sugar and similar substances causes a distinct depression in the digestibility of the substances with which they are fed. By digestion depression is meant the checking of the digestion and an assimilation of the other substances. A number of experiments have been made and others are still in progress to study the influence of Porto Rico molasses on the digestibility of the other ingredients of different rations. The results thus far secured may be stated briefly: —

1. When molasses fed together with hay constituted from 10 to 15 per cent. of the total dry matter of the ration, little if any depression was noted.

2. With molasses composing some 20 per cent. of the dry matter of the hay ration, a depression of 4.5 per cent. was noted in the digestibility of the hay, the digestibility of the dry matter of the latter being 58 per cent. without the molasses, and 55.4 per cent. with the molasses.

3. Molasses and hay would not make a satisfactory combination for any kind of farm stock. A more suitable ration would consist of hay, together with one or more protein concentrates and molasses. Consequently, the effect of the molasses was tested upon a combination of hay and gluten feed. The results of six single trials, in which molasses composed from 17 to 24 per cent. of the dry matter of the ration (average 20 per cent.), show that the dry matter of the combination of hay and gluten without molasses was 72.3 per cent. digestible and 66.5 per cent. digestible when fed with the molasses, hence the molasses caused a depression of 8 per cent. in the digestibility of the hay and gluten.

Early Amber Sorghum.

This plant has again proved its usefulness as a forage crop. Observations have been continued relative to the quantity of seed to be sown broadcast to the acre. Last season as satisfactory results were secured from 60 pounds as from 100

pounds of seed to the acre. The present season three 20-acre plots were each fertilized alike as heretofore and on June 11 the seed was sown broadcast at the rate of 50, 40 and 30 pounds to the acre. In spite of the late seeding and dry August, the crop grew fairly well, and when cut, September 12, was just beginning to head out. The yields, on the basis of one acre, were as follows: —

Seed per Acre.

	50 Pounds Seed to the Acre.		40 Pounds Seed to the Acre.		30 Pounds Seed to the Acre.	
	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).
Plot 1, ...	32,000	6,944.0	-	-	-	-
Plot 2, ...	-	-	29,400	6,556.2	-	-
Plot 3, ...	-	-	-	-	28,800	6,278.4

The yields were not as heavy as were obtained the year previous (20,000 pounds to the acre), owing to the cool, dry August, which did not permit as advanced a development of the crop. From two years' observations it may be concluded that 50 to 60 pounds of seed to the acre are sufficient when sown broadcast for forage purposes. More than this is not necessary; smaller amounts permit a too coarse development of the individual plants, and also gives opportunity for the growth of weeds, especially during the early life of the sorghum plants.

Alfalfa in Massachusetts.

Observations have been continued relative to the suitability of alfalfa as a forage crop in this State. Last year three cuttings were secured from a one-sixth acre plot, equivalent to 3.65 tons of dry hay to the acre (basis of 15 per cent. moisture). The two small plots referred to in the previous report have been combined in one plot one-third of an acre in area. A growth of some 6 to 8 inches was allowed to remain during the autumn of 1906, to serve as a mulch. The plants came through the winter of 1906–07 in excellent condition, and started well in the spring, although the season was some ten days to two weeks late.

The first cutting contained considerable grass in spots, but

yielded at the rate of 2.35 tons to the acre. Unfortunately, through an oversight, the weight of the second cutting (made in early August) was not taken. The third cutting (made September 19) stood about 2 feet high and yielded at the rate of 1 ton to the acre. The weather was very bad during the curing of this cutting, the hay standing in cocks under hay caps for two weeks, being shaken out once during that time. In spite of the bad weather condition, it was fairly well cured and the animals ate it readily. The entire yield for the season, on the basis of 15 per cent. water, must have been at the rate of nearly 4½ tons to the acre. In view of the results thus far secured, the writer is inclined to advise farmers to try alfalfa in a small way, to study its peculiarities carefully, and not to be discouraged if success is not attained at the first trial.

Cost of Rearing Dairy Stock.

The station raises one or two dairy calves yearly to keep up its herd which is being used for experiment purposes. An account has been kept of the food cost involved, and, while the data is not sufficiently complete for publication, it may be said that from $40 to $45 represents the cost of food consumed, when figured at market prices, until the animal reaches two years of age. The animals have been pastured during the summer and for the remainder of the year fed on first and second cut hay, some silage and not over two or possibly three pounds of grain daily. The grain ration has usually consisted of a mixture of bran and fine middlings.

Part II. Dairy and Chemical Studies.

1. The Chemical Composition of Milk.

J. B. LINDSEY.

The larger part of milk consists of water, which contains a variety of substances in suspension and solution. The substances largely dissolved in the water are casein and albumen, milk sugar and the ash or mineral matter, which together form the milk serum.[1] The fat is suspended in the milk in microscopic globules, which are semisolid, and with the serum form what is termed an emulsion.

The multitudinous analyses of milk have shown it to vary widely in composition, depending upon the breed and individuality of the cow, stage of lactation and weather conditions. Food, as a rule, has little effect in permanently changing the proportions of the several ingredients. Numerous authorities state that 100 pounds of milk of average quality should contain the following amounts of the different ingredients: —

		Pounds in 100, or Percentage.
Water,		87.00
Fat,		4.00
Albuminoids	Casein,	3.00
	Albumen,	.50
Milk sugar,		4.80
Ash,		.70
		100.00

The term "total solids" is meant to include all of the ingredients excepting water. For ordinary purposes the chem-

[1] That portion of the casein which can be removed by filtration through filter paper is not generally included in normal serum.

ist determines only the total solids and fat, and obtains the solids not fat by difference. The former two serve as an index of the chemical composition of the milk.

Composition of Milk of Pure-bred Cows.

The following data have been tabulated from authentic sources, in the hope that they will throw light on the composition of milk produced by distinct breeds of dairy cows: —

(*a*) American Data.

1. Jerseys.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months, .	Chicago Exposition,[1] . .	14.00	4.78	9.28
5	6 months, .	Pan-American Exposition at Buffalo.[2]	13.90	4.58	9.32
25	4 months, .	Louisiana Purchase Exposition, St. Louis.[1]	13.50	4.70	8.80
3	One lactation period.	New York Experiment Station.[3]	15.40	5.61	9.80
3	8 months, .	New Jersey Experiment Station.[4]	14.34	4.78	9.56
		Average, 61 cows, . .	13.87	4.77	9.12

2. Guernsey.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months, .	Chicago Exposition,[5] . .	13.78	4.61	9.17
25	6 months, .	Pan-American Exposition at Buffalo.[2]	13.90	4.60	9.30
2	One lactation period.	New York Experiment Station.[3]	14.60	5.12	9.47
3	8 months, .	New Jersey Experiment Station.[4]	14.48	5.02	9.46
2	Probably 7 days.	Wisconsin Experiment Station.[6]	14.46	5.39	9.07
		Average, 57 cows, . .	13.92	4.67	9.25

3. Holsteins.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition at Buffalo.[2]	12.00	3.25	8.75
15	4 months, .	Louisiana Purchase Exposition, St. Louis.[1]	11.30	3.40	7.90
70	Generally 7 days.	Wisconsin Experiment Station.[6]	11.78	3.33	8.45
1	One lactation period.	New York Experiment Station.[3]	12.39	3.46	9.07
3	Eight months,	New Jersey Experiment Station.[4]	12.12	3.51	8.61
		Average, 94 cows, . .	11.73	3.34	8.39

[1] The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638. This paper gives 13.71 as the total solids for Jerseys.

[2] DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).

[3] Tenth report, p. 141.

[4] Report for 1890, p. 223.

[5] Furnished by W. H. Caldwell, secretary, American Guernsey Cattle Club. Hoard's Dairyman gives 13.41 per cent. solids and 4.51 per cent. fat for Guernseys.

[6] Twentieth report, p. 158.

4. *Ayrshires.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.60	3.60	9.00
4	One lactation period.	New York Experiment Station.[2]	13.06	3.57	9.35
3	Eight months,	New Jersey Experiment Station.[3]	12.70	3.68	9.02
		Average, 12 cows, . .	12.78	3.61	9.12

5. *Shorthorns.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
24	3 months, .	Chicago Exposition,[4] . .	12.41	3.64	8.77
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.80	3.57	9.23
25	4 months, .	Louisiana Purchase Exposition, St. Louis.[4]	12.20	3.60	8.60
2	Probably 7 days.	Wisconsin Experiment Station.[5]	12.60	3.52	9.08
		Average, 56 cows, . .	12.36	3.61	8.75

6. *Brown Swiss.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.70	3.63	9.07
5	4 months, .	Louisiana Purchase Exposition, St. Louis.[4]	12.50	3.60	8.90
		Average, 10 cows, . .	12.60	3.62	8.98

7. *Devons.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
2	One lactation period.	New York Experiment Station.[2]	13.77	4.15	9.60

Summary American Data.

Breed.	Number of Cows.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys, ...	61	13.87	4.77	9.12
Guernseys, ...	57	13.92	4.67	9.25
Holsteins, ...	94	11.73	3.34	8.39
Ayrshires, ...	12	12.78	3.61	9.12
Shorthorns, ...	56	12.36	3.61	8.75
Brown Swiss, ...	10	12.60	3.62	8.98
Devons, ...	2	13.77	4.15	9.60

1 DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).
2 Tenth report, p. 141.
3 Report for 1890, p. 223.
4 The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638.
5 Twentieth report, p. 158.

In addition to the above, F. W. Woll[1] gives the following: —

Summary of American Analyses for Butter Fat in Milk of Pure-bred Cows.

Breed.	No. of Cows.	Butter Fat (Per Cent.).
Jerseys,	491	4.98
Guernseys,	191	4.77
Holsteins,	679	3.28
Ayrshires,	108	3.84
Shorthorns,	370	3.73
Brown Swiss,	20	3.78
Devons,	50	4.57

(*b*) Foreign Data.

According to Hucho[2] and Koenig,[2] German authorities, the average composition of the milk of different breeds is as follows: —

Breed.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Holsteins,[3]	12.00	3.25	8.75
Ayrshires,	12.50	3.70	8.80
Shorthorns,	12.90	3.80	9.10
Devons,[3]	13.40	4.40	9.00
Jerseys,	14.70	5.00	9.70
Guernseys,	14.70	5.00	9.70

The average breed tests, conducted at the annual dairy shows of the British Dairy Farmers Associations, 1879–98 inclusive, have given the following results:[4] —

Breed.	Number of Cows	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys,	272	14.46	4.98	9.48
Guernseys,	98	13.50	4.61	8.89
Holsteins,	10	12.25	3.41	8.84
Ayrshires,	42	13.29	4.19	9.10
Shorthorns,	236	12.72	3.75	8.97
Devons,	2	14.34	4.90	9.44

1 Twentieth report, p. 158.

2 Hatch Experiment Station, Bulletin No. 110, pp. 6 and 7. See also Woll's Handbook, first edition, p. 213.

3 Koenig, Die Menschlichen Nährungs- und Genussmittel.

4 Woll's Handbook, fourth edition, 1907, p. 241.

COMPOSITION OF MIXED MILK (LARGELY GRADE COWS, ALL BREEDS).

American and Foreign.

Number Analyses.	AUTHORITY.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
793[1]	Koenig,[2]	12.88	3.69	9.19
200,000	Aylesbury Dairy Company, London,[3] .	12.90	3.90	9.00
4,103	Hatch Experiment Station,[4] . . .	13.63	4.43	9.20
110	Hatch Experiment Station,[5] . . .	13.23	4.49	8.74
5,552	Van Slyke,[6]	12.70	3.90	8.80

Naturally, the larger the proportion of cows in a given area producing thin milk, the nearer will the mixed milk in that area approach 12 per cent. solids; and the larger the proportion of cows in a given area producing thick or rich milk, the nearer will the average of the mixed milk be to 13 per cent. or more of solids.

1 Number of cows.
2 Koenig, Die Menschlichen Nährungs- und Genussmittel.
3 Dairy Chemistry, Richmond, p. 120.
4 Eighteenth report, p. 223.
5 Bulletin No. 110 (Amherst and Northampton Milk Supply).
6 Modern Methods of Testing Milk, p. 15.

2. The Effect of Food upon the Composition of Milk and Butter Fat, and upon the Consistency or Body of Butter.

J. B. LINDSEY.

The writer, together with a number of co-workers, from time to time has conducted a number of long-continued experiments relative to the effect of food and food constituents upon milk, butter fat and butter. Work of this sort is still in progress. The most important results thus far secured may be briefly enumerated below. The full data of the soy bean experiment have not been published.

(a) *Effect on the Milk.*

1. Different amounts of *protein* in the daily ration derived from linseed, cotton-seed, soy bean and corn gluten meals, do not seem to have any pronounced effect in changing the relative proportions of the several milk ingredients.

2. *Linseed oil* in flaxseed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage from 5 to 5.56, and slightly decreased the nitrogenous matter of the milk. This fat increase was only temporary, the milk gradually returning (in four or five weeks) to its normal fat content. The nitrogenous matter also gradually returned to normal, but more slowly than did the fat.

3. Three pounds of *cotton-seed meal* with minimum oil (8 per cent.), when fed daily to each animal, had no noticeable influence on the composition of the milk.

4. The addition of ½ to ¾ of a pound of *cotton-seed oil* to the cotton-seed meal ration appeared to increase the fat percentage of the milk about .4 of 1 per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

5. The substitution of *linseed meal* with a minimum percentage of oil (3 per cent.) in place of the cotton-seed meal and cotton-seed oil resulted in a decline of the fat in the milk to its normal percentage. This change probably was due to the removal of the cotton-seed oil from the ration, and not to the influence of the linseed meal.

6. The addition of .6 of a pound of *corn oil* to a ration made up of a mixture of grains low in fat increased the fat percentage of the milk .23 per cent. (5.17 to 5.40). At the end of two weeks the effect of the corn oil had disappeared, and the milk had returned to its normal fat content.

7. The sudden removal of the *corn oil* from the daily ration caused a drop of .54 per cent. in the fat (4.97 to 4.43), but after the first week the normal fat per cent. was again present.

8. *Corn oil* appeared to have depressed the nitrogen percentage of the milk by .034 per cent. (.610 to .576), the nitrogen gradually returned to its normal percentage after the feeding of the corn oil had ceased.

9. *Corn meal* (a carbohydrate feed) was without effect on the composition of the milk.

10. Two to 3 pounds of *soy bean meal* with a minimum oil percentage (8 per cent.), fed daily to each animal, did not appear to in any way modify the proportions of the several milk constituents.

11. The addition of ½ to 1 pound daily of *soy bean oil* to a basal ration of grain and hay very slightly increased the fat percentage in the milk during the first two or three weeks (.10 per cent.). No other variation was noted.

12. The sudden removal of the *soy bean oil* from the ration caused a drop of .25 per cent. of the fat percentage of the milk. At the end of three weeks the milk had not regained its normal fat percentage.

(*b*) *Effect on Butter Fat.*

13. *Corn gluten* and *linseed meals* with a minimum percentage of oil (3 per cent.) produced a normal butter fat. *Cotton-seed and soy bean meals* with a minimum oil percentage (8 per cent.) likewise effected little change in the composition of the butter fat. *Corn meal* was without noticeable influence on the composition of the butter fat.

14. *Linseed oil* (1.4 pounds digestible oil per head daily)

produced a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and olein percentage (soft fat).

15. *Cotton-seed oil* (.5 pound daily per head) increased the melting point and the olein percentage of the butter fat.

16. *Corn oil* (.6 pound per head daily) decreased the volatile fats and increased the percentage of olein; the melting point of the fat remained unchanged.

17. *Soy bean oil* (.50 to 1 pound daily per head) caused a drop in the saponification number of some 10 points, a decrease in the soluble fatty acids and in the volatile fatty acids (Reichart-Meissl number), an increase in the iodine number (percentage of olein) from 32 to 40, while little or no change was noted in the melting point of the butter fat.

18. A rise in the iodine number (increase of olein) is a reasonably sure indication of a soft-bodied butter which will lack in firmness at a temperature of 70° F. An increase in the melting point of the butter fat is not a sure indication of a harder, firmer butter. It seems evident that the proportions of the several fats is more or less changed by an excess of oil in the feed and that this change of proportions varies the melting point in the fat in some such way as the melting point of a mixture of metals is changed by the resulting amalgamation.

(c) *Effect on Butter.*

19. The effect of *linseed meal* with a minimum percentage of oil (3 per cent.) on the general character of the butter was not positively identified.

20. *Cotton-seed meal* with a relatively high oil percentage (12.6 per cent.) produced butter that was rather crumbly when hard, and slightly salvy to the taste. Cotton-seed meal with a minimum percentage of oil (8 per cent.) likewise produced a hard, firm butter.

21. *Corn gluten meal* with a minimum percentage of oil (2 to 3 per cent.) produced a rather soft, yielding butter.

22. *Soy bean meal* with minimum oil (8 per cent.) produced butter that was rather softer and more yielding to the touch than that derived from a grain ration composed entirely of bran, ground corn and oats, gluten feed and cotton-seed meal.

23. An excess of *linseed oil* (1.4 pounds digestible oil per head daily) produced a very soft, salvy butter, with an inferior flavor.

24. The addition of *cotton-seed oil* (.5 pound per head daily) to a normal ration, or to one containing 3 pounds of cotton-seed meal low in oil, produced a softer, more yielding butter than that produced by the ration with the oil omitted.

25. The addition of *corn oil* (.6 pound daily per head) to a normal ration containing 2 pounds of corn gluten meal low in oil produced a noticeably softer butter than when the oil was omitted.

26. *Corn meal* tended to produce a reasonably hard, firm butter, of an agreeable flavor.

27. *Soy bean oil* (.5 to 1 pound daily per head) added to a grain ration produced a butter that was noticeably soft and yielding to the touch, and that would not stand up well at 70° F. and above.

The experiments thus far completed enable one to draw the following general conclusions: —

1. Neither the *proteid* nor the *carbohydrate groups*, when fed in normal amount, have any noticeable influence in changing the proportions of the several milk ingredients, nor in modifying to any marked degree the character of the butter fat as revealed by the ordinary chemical tests; such changes, so far as they are the result of food, are due to the presence of oil in the feed stuff.

2. Some proteids produce a harder, firmer butter than others, while the tendency of starchy foods is to produce a firm-bodied butter. *Vegetable oils* in excess of the normal amount produce a noticeably soft-bodied butter.

3. It is not considered advisable to feed large quantities of oil to cows, it having a tendency to derange the digestive and milk-secreting organs.

4. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, skill and care of the butter maker, and especially upon the character of the starter employed. Normal feed stuffs must be considered of secondary importance in establishing butter flavor.

3. Standard for Babcock Glassware.

E. B. HOLLAND, M.S.

The Massachusetts Legislature, in the spring of 1901, enacted a measure entitled "An Act to provide for the protection of dairymen,"[1] which took effect the first of July of that year. This dairy law, so called, required, among other things, that Babcock glassware should be tested for accuracy, and made it the duty of the director of the experiment station or his agent.[2] The statute designated no standards whatsoever, leaving the matter entirely to the discretion of the experiment station. After visiting several stations and consulting the official having charge of such work, a standard, methods of testing and an allowable limit of error, conforming in general to the requirements of other New England States, were adopted provisionally and published in the fourteenth and fifteenth annual reports of this station.[3]

Up to the end of the last fiscal year (Dec. 1, 1907), 18,855 pieces of glassware had been tested, of which 1,770 pieces, or 9.39 per cent., were condemned. The yearly totals recorded below show marked variations, but with a high average percentage of inaccuracy.

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[1] Acts and Resolves of Massachusetts for 1901, chapter 202, sections 1–7, Revised Laws of Massachusetts for 1902, chapter 56, sections 65–69.

[2] Sections 1, 2.

[3] Hatch Experiment Station, annual reports for 1901 and 1902.

Amount of Glassware tested.

Year.	Total Number of Pieces.	Number Inaccurate.	Per Cent. Inaccurate.
1901,	5,041	291	5.77
1902,	2,344	56	2.39
1903,	2,240	59	2.63
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
Totals,	18,855	1,770	9.39 [1]

The grand totals may be further subdivided into the several classes of glassware of which they were composed: —

Character of Glassware tested.

Kind.	Total Number.	Number Inaccurate.	Per Cent. Inaccurate.
Cream bottles,	7,714	710	9.20
Milk bottles,	6,826	784	11.49
Skim milk bottles,	675	106	15.70
Pipettes,	2,834	69	2.43
Acid measures,	806	101	12.53
Totals,	18,855	1,770	9.39 [1]

The manufacturers repeatedly protested against the refusal of their glassware, and asserted that similar shipments were passed in other States. Such might easily have been the case, where the error was small, due to differences in method of testing or in allowable limit of error, possibly both. In some instances the condemned pieces were forwarded to another station and retested, but even this apparently failed to satisfy the manufacturers. It became evident that further investigation was necessary in order to bring the matter to an unquestionable basis and to remove all reasonable grounds for complaint.

[1] Average.

Original Standard.

Dr. Babcock,[1] originator of the method, laid down the following requirements relative to the graduation of bottles: —

The 10 per cent. of fat represented upon the necks of the bottles correspond to a volume of 2 cubic centimeters.

In addition, this is stated to be equivalent by weight to 2 grams of water or 27.18 grams of mercury (specific gravity 13.59). No mention of temperature being made, presumably 60° F. was intended. This would indicate the Mohr cubic centimeter, and is supported by a statement of the Emil Greiner Company, under date of Dec. 3, 1906: —

When we made the first bottles for Dr. Babcock, nearly twenty years ago, we were simply told to graduate the space of 2 cubic centimeters into 50 parts, and each five parts representing 1 per cent. butter fat. Therefore, 1 per cent. is .2 of a cubic centimeter, and at that time the Mohr cubic centimeter was considered the standard.

Concerning the graduation of pipettes, Dr. Babcock stated: —

It should contain, when filled to the mark, 17.6 cubic centimeters . . . (and) . . . will deliver a little less than 17.5 cubic centimeters of milk.

Capacity in Mohr cubic centimeters was evidently the intent of the graduation.

Manufacturers' Basis of Graduation.

The eastern trade in Babcock glassware is largely supplied by three manufacturers, the Emil Greiner Company of New York, Kimball Glass Company of Chicago and Wagner Glass Works of New York. Upon request, the above firms furnished the following data relative to their standards of graduation. The Emil Greiner Company employed the Mohr cubic centimeter (1 gram of water at 15° C.), and calibrated with either water or mercury (specific gravity 13.6 at ordinary room temperature). The Kimball Glass Company used the true cubic centimeter, and calibrated with mercury (specific gravity

[1] Wisconsin Agricultural Experiment Station, seventh (1890), ninth (1892) and tenth (1893) annual reports.

13.5463 at 20° C.). The Wagner Glass Works reported 1 cubic centimeter as equal to 13.59 grams of mercury at 60° F., which was probably the Mohr cubic centimeter.

The differences were not large or the errors especially serious, but the need of a scientific standard was unmistakable, if uniformity was to be secured with a safe interchange of apparatus. Only the *limit* of error has permitted the interchange of apparatus in the past, which is a point to be noted.

Reasons for a New Standard.

With these facts at hand, it was necessary to submit the case to some recognized authority for a decision, or at least advice as to what action ought to be taken. This plan also seemed the most promising for the reason that the two parties interested, the manufacturers[1] and the State officials,[2] neither agreed with each other nor among themselves as to a standard or methods of testing. The matter was finally referred to the National Bureau of Standards at Washington, as the body best fitted to deal with the case. Director Stratton[3] wrote as follows: —

> We are decidedly of the opinion that there would be less likelihood of errors in milk-testing work if all volumes were expressed in true cubic centimeters. It of course does not make any difference what unit is used, provided the same one is used to measure the milk sample and the fat; but if — as might easily happen — the pipettes used to measure the milk are graduated on one basis and the neck of the flask on another basis, serious errors might be introduced in the result.
>
> Referring again to the question of graduating Babcock ware for testing milk, which we have given some attention, we hope that you will see your way clear to adopt as the unit in this work the true cubic centimeter at 20° C. This, we feel confident, will prevent confusion in the end, by bringing the apparatus used in testing milk and other dairy products in agreement with the volumetric apparatus used by chemists in general. While the practice of using the gram of water at a certain temperature may have possessed some advantages in Mohr's days, we doubt very much whether it would be any convenience to use such units as the gram of water at 15°, 17.5° or 20° at the present time.
>
> The use of the true cubic centimeter is necessary in all absolute work, and it cannot under any circumstances be dispensed with.

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[1] *Loco citato.* [2] Station reports and correspondence. [3] Correspondence.

New Standard.

The recommendation by the Bureau of the true cubic centimeter as the basis of graduation, because it is a well-defined unit, universally recognized, and for uniformity in volumetric apparatus, appeared worthy of acceptance. The standard or basis of graduation was eventually drafted as follows: —

SECTION 1. The unit of graduation for all Babcock glassware shall be the true cubic centimeter (0.998877 grams of water at 4° C.).

(*a*) With bottles, the capacity of each per cent. on the scale shall be two tenths (0.20) cubic centimeter.

(*b*) With pipettes and acid measures, the delivery shall be the intent of the graduation and the graduation shall be read with the bottom of the meniscus in line with the mark.

As the necessary change in graduation is slight and the manufacturers few in number, there appear no serious obstacles in the way of the adoption of the new standard, though one firm opposed it as impracticable.

Methods of Testing.

(*a*) *Babcock Bottles.* — Of the several methods[1] in vogue for testing Babcock bottles, calibration with a weighed amount of mercury was the most sensitive, because of the high specific gravity of the metal. The process had also the advantage of being generally understood and extremely simple. The figures assumed for the specific gravity of mercury, however, have usually been too high. According to the Bureau of Standards,[2] 1 cubic centimeter at 20° C. should weigh in air against brass weights 13.5471 grams. The official method was readily deduced from the above.

SECTION 2. The official method for testing Babcock bottles shall be calibration with mercury (13.5471 grams of clean, dry mercury at 20° C., carefully weighed on analytical balances, to be equal to 5 per cent. on the scale), the bottle being previously filled to zero with mercury.

[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, pp. 280, 281; Vermont Agricultural Experiment Station, fourteenth (1901) annual report, pp. 222, 223; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 221, 222; tenth (1893) annual report, p. 125; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 47-53; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, pp. 45-49.

[2] Correspondence.

The provision as to clean, dry mercury weighed on analytical balances should be carefully observed. The scale equivalent in mercury of the ordinary bottles is stated below, and that of any other percentage can be readily calculated : —

Kind.	Capacity, in Per Cent.	Grams of Mercury at 20° C.
Cream bottles, ...	50.00	135.4710
Cream bottles, ...	30.00	81.2826
Milk bottles, ...	10.00	27.0942
Skim milk bottles, ...	.50	1.3547

A number of quick methods, that are reasonably sensitive, are employed to cull out the questionable bottles. For such a purpose they are extremely valuable, but they should never be considered official. This idea was incorporated into a section.

SECTION 3. Optional methods. The mercury and cork, alcohol and burette, and alcohol and brass plunger methods may be employed for the rapid testing of Babcock bottles, but the accuracy of all questionable bottles shall be determined by the official method.

(*b*) *Pipettes and Acid Measures.* — With Babcock pipettes and acid measures, as with other volumetric apparatus of similar character, the *delivery* is, or should be, the intent of the graduation. There has been considerable discussion on this point, but the recognized practice should not be set aside and an exception made in this case. Relative to pipettes, Director Stratton [1] wrote as follows : —

The basis of test is the actual volume of water *delivered* by the pipette when used in the manner specified under Regulations for Testing.[2]

He also went on to say that, while he could not state in absolute terms the accuracy of such pipettes when used for milk, in his opinion the error would not exceed .1 cubic centimeter. In other words, a 17.6 cubic centimeter pipette would deliver in milk approximately 17.5 cubic centimeters, — what has usually been assumed. Probably this difference with milk is largely due to viscosity, though other factors enter in. Calibra-

[1] Correspondence. [2] Circular No. 9, third edition.

tion with mercury is not permissible, as it involves many points of uncertain value, and all tests[1] based on *capacity* should be excluded.

SECTION 4. The official method for testing pipettes and acid measures shall be calibration by measuring in a burette the quantity of water (at 20° C.) delivered.

Limit of Error.

The demand of State officials as to accuracy and the claims of manufactures as to their ability to graduate within definite limits agreed very closely, consequently there was little difficulty in presenting figures acceptable to both parties.

SECTION 5. The limit of error.

(*a*) For Babcock bottles, it shall be the smallest graduation on the scale, but in no case shall it exceed five tenths (0.5) per cent., or for skim milk bottles one hundredth (0.01) per cent.

(*b*) For full quantity pipettes, it shall not exceed one tenth (0.1) cubic centimeter, and for fractional pipettes five hundredths (0.05) cubic centimeter.

(*c*) For acid measures, it shall not exceed two tenths (0.2) cubic centimeter.

The new standard was submitted to Dr. Babcock, and passed without criticism. It was also sent to Professor Woll, referee on dairy products for the association of official agricultural chemists, to be presented at the 1907 meeting, but by some oversight was not forwarded to the secretary. It will be offered at the next annual meeting.

It is desired to acknowledge the valuable assistance of the manufacturers, Director Stratton and station officials, for without their co-operation the proposed standard would not have been deduced.

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[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, p. 281; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 222, 223, tenth (1893) annual report, p. 126; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 53, 54; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, p. 49.

REPORT OF THE BOTANISTS.

G. E. STONE, BOTANIST; G. H. CHAPMAN, ASSISTANT.

1. Outline of the year's work.
2. Seed work.
3. Seasonal peculiarities.
4. Premature defoliation of trees.
5. Asparagus rust.
6. Asparagus fusarium.
7. Peony troubles.
8. Potato diseases.
9. Experiments with fungicides.
10. Influence of potash salts on potato scab.
11. Investigations relating to mosaic disease.
12. Some factors which underlie susceptibility and immunity to disease.

1. Outline of the Year's Work.

G. E. STONE.

During the past year attention has been given to the following lines of work: correspondence; observations on and investigations of various diseases; seed separation; seed germination and seed purity testing; mechanical analyses of soils; the study of mosaic troubles of tobacco and other crops; the testing of banding substances for trees; investigations of tomato rot; experiments with the spraying of potatoes; the study of the effects of temperatures, moisture, light, etc., on greenhouse crops; and a study of the meteorological conditions affecting plant diseases and the development of crops.

Mr. N. F. Monahan, who has been connected with the department since his graduation in 1903, resigned to take up practical greenhouse and market-garden work, and his place has since been filled by Mr. G. H. Chapman of the class of 1907.

From the pathologist's standpoint every season possesses distinct individuality, and the past season has been no exception in this respect. Since the meteorological conditions are never identical in any two seasons, plant diseases show considerable variation; and, while an exceptionally dry summer like the past may be conducive to the favorable development of some crops, it is also the means of checking that of others by favoring certain plant diseases. The long period of drought was especially severe for lawns, trees and shrubs, the effect being much more pronounced in the eastern than in the western part of the State.

During the year the department has changed its headquarters from the east experiment station to Clark Hall, a new building located on the college grounds, and its equipment has been enlarged to meet the increased demand of certain lines of work.

We have been obliged to sacrifice much valuable time from experiment work, owing to the difficulty experienced in moving and setting up equipment, and it has been necessary to omit certain lines of investigation from this report.

2. Seed Work.

Work has increased in this line to some extent during the past year, 359 samples of seeds having been tested and separated in 1907, as compared with 231 in 1906. During the year many improvements have been made in the appliances used for separating seed. A Bishop & Babcock blower has been installed for the separation of tobacco seed, and altogether much attention has been given to the development of improved apparatus for this work, which has resulted in the production of an exceptionally efficient method. Arrangements have also been made for separating onion seed by electric power. Constantly increasing interest is being shown in seed testing and seed separation, and in this State as well as others considerable interest has been aroused in making people realize the necessity for pure seed.

The following tables give in brief the seed work done in 1907: —

Table I. — *Records of Seed Germination, 1907.*

Kind of Seed.	Number of Samples.	Germination.		
		Average Per Cent.	Highest Per Cent.	Lowest Per Cent.
Onion,	40	86	98.5	57
Tobacco,	2	91	92	90
Corn,	9	63	100	–
Timothy,	4	98	100	96
Celery,	3	83	91	70
Miscellaneous,	189	44	100	–
Total,	247	–	–	–

Table II. — *Records of Seed Separation, 1907.*

Kind of Seed.	Number of Samples.	Weight in Pounds.	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	27	425	87.4	12.6
Tobacco,	85	47	84.5	15.5
Total,	112	–	–	–

The average germination of onion seed for 1907 was 86 per cent., and that of the preceding year 79 per cent., showing a better grade of seed for 1907 than 1906, so far as its germinating capacity is concerned. Some of the corn sent in did not germinate with repeated tests, which was apparently due to the immaturity of the seed.

The miscellaneous seeds in this list consist largely of flower and vegetable seeds. Some white pine seeds were tested, the per cent. of germination being 59, while frequently white pine seeds do not give more than 33 per cent. of germination.

Only 4 per cent. was discarded from the best tobacco seed by the process of air separation, while from the poorest sample 33 per cent. was discarded. At the present time most tobacco men grow their own seed, selecting carefully those plants representing the best types of tobacco; consequently, the seeds which are sent to us contain considerable chaff, which is blown out and included in the percentage of discarded seed. By this process of selection a more uniform type of tobacco is obtained and improvements in the crop rendered possible.

In the case of the best onion seed 1.6 per cent. was discarded by the use of the winnowing machine and 43.3 per cent. from the poorest sample.

The separation of tobacco and onion seed is quite generally acknowledged to be a wise course, and it is being practised extensively among growers in the Connecticut valley. In our opinion, this discarding of the inferior seed should be given more attention.

Seed to be tested or separated should be sent by either mail or express to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass. The work is done gratuitously by the station for people living in the State, but the postage or express charges should be paid by the person sending the samples.

3. Seasonal Peculiarities.

The extreme conditions which have prevailed during the past four years have been the cause of much injury to vegetation. In previous reports attention has been called to some of these troubles, more particularly to the extensive winter-killing which caused so much injury during the winter of 1903–04, at which

time thousands of trees and shrubs were severely affected, many having been dying slowly ever since. Besides the trees which are dying, there are many others which are in a very weakened condition. Numerous oaks which were injured four years ago have died during the past two years, and some of those not yet dead are gradually becoming weaker. These trees are more noticeable in the eastern part of the State, and our attention has repeatedly been called to the serious condition of the elms, due to the same cause. Some very large specimens of this tree have died, and others are in poor condition.

Mention has previously been made in our reports of the condition of the red maples, many of which are now gradually dying, and the white and rock maples are suffering to a limited extent from the same cause. During the past spring some damage was done to the foliage of these trees by the late frosts.

The condition of the white pine roots has already been referred to a number of times in previous reports. Examinations of these have for the past four years been repeatedly made in various parts of the State, and it has been found that the injury to the fibrous roots is largely responsible for the poor condition of the foliage; but the present condition of the pine roots is much more alarming, since during the past year in a very large number of cases the small feeding roots have collapsed. This is true not only of those trees which show injury from sun scorch, but of those which appear to be perfectly healthy.

Our extensive observations connected with the effects of meteorological conditions on plants have led us to examine hundreds of roots in different localities, and we have found this poor condition of the roots to be widespread and serious. The injury involving the larger fibrous roots was observed extensively four years ago, but that affecting the smaller fibrous roots was not noted in connection with the pine until last summer.

Sun Scald.

The trunks of many apple trees which were affected by sun scald four years ago may be noticed at the present time. Two years ago a great many apple trees again showed the effects of sun scald, which was in many cases followed by canker, and this is very noticeable throughout the State on those trees

which have not been pruned. It affected only the lower, shaded limbs, however, and is of little importance, being scarcely perceptible in properly pruned and well-cared-for orchards. The sun scald of two years ago affected many of our wild plants, causing much injury to the wild cornels, particularly to *Cornus stolonifera*, Michx., and *C. circinata*, L'Her.

During the past spring practically every sycamore lost its leaves when they were half grown, from the same cause, and an examination of the young wood of the sycamores showed that all last year's growth was injured; but as the sycamore is a difficult tree to kill by defoliation, from whatever cause, buds were thrown out from the old twigs, and the trees subsequently bore a good crop of foliage. The sycamore often becomes defoliated in early summer from the effects of the fungus *Glœosporium nervisequum* (Fckl.) Sacc., but always succeeds in providing itself with new foliage in a short period of time. Sun scald is a common trouble, and can be easily produced in the laboratory. Our attention has often been called to the sun scald of apple trees, caused by banding with tarred paper, showing that tarred paper should not be used around apple trees without taking precautions.

Sun Scorch.

The past season has been very favorable for sun scorch, this trouble having been much more severe in the eastern part of the State, where the effects of the drought were more marked. Sun scorch is prevalent every summer on certain trees, especially those located in dry soil, and rock maples are peculiarly susceptible in this respect. This season the white pine also sun scorched badly, the injury appearing to be much more general than that which occurred three years ago, but less severe on the foliage, since in practically all cases the burning was confined to the apical portion of the needle, and seldom extended to the base. If the needles are not wholly destroyed, no great injury results, and a large number of the trees which were burned three years ago have entirely recovered. Should nothing further affect the pines, and the condition of the roots improves, the present burning will be scarcely perceptible one year from

now, as it is a matter of general observation that many of the trees which burned this season commenced to recover a few weeks after being affected.

Strong, dry winds are important factors in producing sun scorch, and an excellent illustration of this may be found in the ninth annual report of the Hatch Experiment Station (pp. 81, 82); but, technically speaking, the cause of sun scorch is the exhalation of watery vapor from the foliage in excess of the amount of water supplied by the roots. Sun scorch is a common phenomenon, peculiar to many plants, and, while its occurrence on the pine appears to be new to most people, we have observed it for twenty-five years to a very limited extent. The cause of the recent sun scorch of the maple and white pine is to be found in certain meteorological conditions, but the immediate cause may be traced to the peculiarly dry winds of July, together with the inability of the roots to supply sufficient water. The effect of sun scorch is more marked on the western side of a tree or forest, — a fact which has been noted by various observers besides ourselves.

4. Premature Defoliation of Trees.

The premature defoliation of trees, which has been very common this season and which occasioned considerable correspondence, as usual, gives rise to much unnecessary anxiety. Among the many well-known causes of defoliation may be mentioned severe drought, and even excess of water may cause it. Elm trees, however, are likely to lose their leaves both in early summer and fall, and this is also common to other trees; but the loss of foliage in the case of the elm is seldom serious enough to cause alarm; and even the shedding of the twigs of the elm, which occurs to considerable extent, often periodically, generally causes little damage.

5. Asparagus Rust.

This disease has been more prevalent than usual the past summer in certain localities, but less so in others. It has in some places affected those beds which in ordinary seasons seldom show outbreaks except in the late fall. The rust occurred in a rather unusual form for this section, since as a

rule the summer stage (uredospore), which causes practically all the injury, was checked, and as a result the fall stage (teleutospore) developed early in the summer. This often occurs on beds which never suffer materially from the rust, but it is the first instance noticed in this section of the uredospore stage being supplanted by the teleutospore stage in midsummer on beds which are usually infected with the uredospore stage, and which suffer more or less loss from such infection. This supplanting of the summer stage by the fall is an advantage to the crop, as the fall stage causes little damage, and there is not the slightest opportunity for infection during the summer, as the teleutospores do not germinate until they are given a resting period. Prof. R. E. Smith[1] has shown that this often occurs in California, attributing it to a lack of atmospheric moisture.

6. Asparagus Fusarium.

During the past few years our attention has been called to an apparently new fungous trouble affecting asparagus, which has appeared in some instances in the spring, attacking the fresh, marketable shoots. On one bed it occurred two years ago, but the owner has not been troubled with it since. In this case the young, tender shoots rotted off near the surface of the ground, and an examination of the soft rot in the tissue revealed that the asparagus shoots were infected with a species of fungus known as fusarium. Many instances of fusarium infection have also been observed by us later in the season on the mature stalks, the infected stalks being contorted in their growth and often split open, and an examination of these stalks always reveals a dense growth of this fungus.

7. Peony Troubles.

For two years we have had complaints in regard to a serious trouble of the peony, concerning which much has been written in the florists' journals. The disease is characterized by the dying of the plant to the ground, and an examination of the portion under ground usually reveals a decidedly bad state of affairs. In most of the specimens examined, the crown of the

[1] The Water Relation of *Puccinia Asparagi*. R. E. Smith, Bot. Gaz., Vol. 38, July, 1904, pp. 19–43.

plant, which is located just below the surface, is more or less blackened and decayed, and often dead, the black areas and decayed spots frequently extending below the crown of the plant for some distance. Microscopic examinations of the rather limited material which we have had at hand have revealed no specific organisms associated with this trouble, although fungi, bacteria and eel worms are usually found in the decayed tissue, apparently as secondary factors or accompaniments of decay. In one instance plants were observed which had perfectly clean cavities in the crown, as though eaten out by some small animal; and in other instances the so-called club-foot or gall formation, containing eel worms, was noticeable on the roots, but these did not seem to be responsible for the trouble. Further investigations of this disease are at present under way.

8. Potato Diseases.

Potato foliage went through the season with comparatively little disease. There was no blight of any importance. Some potato crops always die down or mature earlier than others, which is due in part to the conditions under which they are grown, though it is often believed that this early maturity is caused by some blight. The abundance of rain in the fall, which followed the long drought, caused potatoes to rot badly in some cases, especially when located on low and not easily drained soil, but on the whole the season was favorable for potatoes, the dry summer holding in check certain fungi which are likely to be troublesome, especially during a wet summer. On some fields, late in the season, following the period of rain, a rather unusual outbreak of *Cladosporium fulvum*, Cke., occurred, although this fungus is usually confined to tomatoes in this section.

9. Experiments with Fungicides.

Some potato-spraying experiments were made on the station plots, for the purpose of testing and comparing certain spraying mixtures to discover their adhesive properties, as well as their value as fungicides. As there was little fungous infection on the potato during the summer, the deductions which were drawn from the various applications of fungicides are not of great value.

The plots selected were those which were being used in the agricultural department for testing the relative value of potash compounds,[1] and for our purposes five of these were used. With the exception of two plots, the standard Bordeaux mixture formed the basis of the fungicides, the regular 4 — 4 — 50 formula being used. The plots were tested as follows: —

Plot 1 was treated with Bordeaux and Paris green, 1 pound of Paris green being added to 50 gallons of the Bordeaux.

Plot 2 was treated with Bordeaux and "Disparene," or arsenate of lead, 5 pounds of "Disparene" being added to 50 gallons of the Bordeaux.

Plot 3 was treated with Bordeaux and sodium benzoate, 4 to 6 ounces of the sodium benzoate being added to 50 gallons of the Bordeaux mixture.

Plot 4 was treated with soda Bordeaux and Paris green, 1 pound of Paris green being added to the soda Bordeaux mixture.

The soda Bordeaux is made as follows: —

Soda (commercial lye),	2 lbs.
Copper sulfate,	6 lbs.
Lime,	½ to ¾ lbs.
Water,	60 gals.

The mixture was tested to insure its alkalinity, and the amount of lime was modified according to the strength of the lye.

Plot 6 was treated with copper phosphate and "Disparene." Copper phosphate is a compound prepared by the Bowker Chemical Company, and is being tested as a fungicide. Our formula is as follows: —

Copper phosphate,	5 lbs.
"Disparene,"	5 lbs.
Water,	50 gals.

The plots were sprayed July 6, when the sun was shining, in the order given in the outline, the ordinary barrel spray pump being used. No rain fell before the first observations were made on July 11. The potato bug and flea beetle were present

[1] See report of the agricultural department, p. 145.

in abundance before the plants were sprayed. The results of the observations of July 11 are given below: —

Plot 1. Bordeaux and Paris Green mixed: —

No live potato bugs found.
The flea beetles scarce.
The mixture colored the leaves well.

Plot 2. Bordeaux and "Disparene" mixed: —

No live potato bugs found.
Flea beetles scarce.
The mixture seemed to adhere rather better than the Paris green, and covered the plants more evenly.

Plot 3. Bordeaux and Sodium Benzoate: —

A few potato bugs found on this plot.
Flea beetles scarce.
Color not very strong.
The mixture adhered well.

Plot 4. Soda Bordeaux and Paris Green: —

No potato bugs found.
No flea beetles found.
No strong color shown on plants.

Plot 5. Copper Phosphate and "Disparene": —

No potato bugs found.
Flea beetles very scarce.
Mixture does not color plants to any appreciable extent.

Although careful observations were made from day to day on the general appearance of the field, and the presence and absence of bugs noticed, by the time set for a second spraying no material difference in appearance was noticeable. Without exception the plants maintained the same condition, *i.e.*, they were free from potato bugs and flea beetles. One plot, that on which sodium benzoate was used, did seem toward the last to have rather more flea beetles and potato bugs than the others, although these were not in sufficient numbers to do any but local damage. There was absolutely no sign of burning of the leaves or stems on any of the plots.

The field was sprayed as before for the second time on July 22. The night after the spray was applied it rained heavily, and most of the spray was apparently washed off; but when the field was examined on July 29 no potato bugs were found, and there was no sign of blight. There was no appreciable leaf burning except in a few isolated cases, and in all these the

plants affected were small and weak, and had not made the growth of the others.

One week later the field was sprayed for the last time, as after this the plants became too large to be sprayed again. During the month of August the plants were inspected from time to time, but no late blight (*Phytophthora infestans*, (DBy)) occurred. In the first week in September, however, a disease appeared which seemed to make headway on some parts of the field, although of no general occurrence on potatoes. This was *Cladosporium fulvum*, Cke. A period of wet weather lasting about a week and a half occurred just after the Cladosporium was noticed, and under these favorable conditions the disease spread rapidly in some sections of the field.

No more observations were taken of the plots until September 16, when the field was again examined carefully, both with reference to the diseases present, the general appearance of the plots and the maturity of the plants. These results were the last taken before the potatoes were dug, and are given below.

Regarding the diseases present on the different plots treated with the spraying mixtures, it was found that plot 1 sprayed with Bordeaux and Paris green, showed the presence of both Alternaria and Cladosporium, although these diseases were found only in localized areas, and could not be considered as especially destructive to the plants. The Bordeaux and Paris green is productive of fairly good results, but does not prove to be so efficacious as some of the mixtures used on the other plots.

Plot 2, treated with Bordeaux and "Disparene," presented a better appearance than did plot 1, and showed very little Cladosporium or Alternaria. This was due to the fact that the mixture adhered to the leaves for a longer time, and was not so easily washed off as the Paris green-Bordeaux mixture.

Plot 3 was sprayed with Bordeaux and sodium benzoate, and the plants proved to be in exceptionally fine condition, practically no Alternaria or Cladosporium being found even on dead plants. This mixture, although not coloring the leaves to any appreciable extent, seemed to adhere better than any of the others, with the exception of that used on plot 4.

Plot 4 was sprayed with soda Bordeaux and Paris green,

and when the observations were taken showed no Alternaria or Cladosporium, the whole plot presenting a good appearance. This mixture adhered to the leaves the best of any and possessed the advantage of not coloring the plants to any great extent.

Plot 5 was sprayed with copper phosphate and "Disparene," and was in very poor condition when examined. The whole plot was badly affected with both Alternaria and Cladosporium, and little good seemed to result from spraying with this mixture.

The following table shows the relative appearance of the sections of each plot: —

TABLE III. — *Showing the Relative Difference in the Condition of Each Plot, Sept. 16, 1907.*

Section.	TREATMENT.	PLOT 1. Bordeaux and Paris Green.	PLOT 2. Bordeaux and "Disparene."	PLOT 3. Bordeaux and Sodium Benzoate.	PLOT 4. Soda Bordeaux and Paris Green.	PLOT 5. Copper Phosphate and "Disparene."
Section 1,	No potash, . .	½ dead,	All dead,	All dead,	All dead,	All dead.
Section 2,	Kainit, . . .	¾ dead,	¾ dead,	¼ dead,	½ dead,	⅜ dead.
Section 3,	High-grade sulfate of potash.	¾ dead,	½ dead,	¼ dead,	¼ dead,	¾ dead.
Section 4,	Low-grade sulfate of potash.	½ dead,	½ dead,	¼ dead,	½ dead,	⅞ dead.
Section 5,	Muriate of potash, .	¾ dead,	¾ dead,	⅜ dead,	⅜ dead,	¾ dead.
Section 6,	Nitrate of potash, .	½ dead,	½ dead,	⅜ dead,	½ dead,	¾ dead.
Section 7,	Carbonate of potash,	¼ dead,	¾ dead,	½ dead,	½ dead,	¾ dead.
Section 8,	Silicate of potash, .	⅜ dead,	⅛ dead,	¼ dead,	¼ dead,	⅞ dead.

Of the different spraying treatments the copper phosphate shows the largest percentage of dying plants, and, as already stated, this plot was the most severely affected with fungi. The other plots which showed less infection were treated with Bordeaux mixture in some form of combination. The application of Bordeaux mixture is known to prolong the maturity of crops, and no doubt the difference in the maturity of the plots treated with the Bordeaux mixture and those treated with copper phosphate is due in part to the tonic effect of the Bordeaux. Too much reliance, however, cannot be placed upon these conclusions as they represent only one season's work, and the following summary must be interpreted with caution.

Summary.

I. Of the sprays used this year on the experimental plots, the soda Bordeaux and Paris green was the best. It adhered to the leaves the best of any used, it did not color the foliage greatly, and effectively prevented the plants from being injured by either fungi or insects. In mixing this spray, however, *great care should be taken to add sufficient lime to make the mixture slightly alkaline, otherwise serious leaf burn might result.*

II. Bordeaux and sodium benzoate ranked a close second in effectiveness, and hardly any discrimination can be made between the soda Bordeaux mixture and the benzoate mixture. This mixture colors the leaves scarcely at all, and adheres about as well as the soda Bordeaux. The sodium benzoate could be added in slightly larger amounts without injury to the plants.

III. Bordeaux and "Disparene" seemed to be productive of fairly good results, and held the blight and insects well in check. It did not, however, give such good results as the first two mentioned. It showed up well on the foliage, coloring it heavily, and it adhered well to the leaves.

IV. Bordeaux and Paris green did not seem to hold the diseases in check as well as some of the other sprays, and did not adhere as well to the leaves; nevertheless, it was productive of good results.

V. Copper phosphate and "Disparene" seemed to have no appreciable effect on checking the disease, and this year's results, at least, seem to indicate that it is not equal to other fungicides.

10. Influence of Various Potash Salts on Potato Scab (*Oospora scabies*, Thaxter).

In connection with the preceding spraying experiments on potatoes, observations were made on the occurrence of potato scab in the various plots treated with different combinations of potash.[1] As previously stated, there were five series, each containing eight plots, fertilized with seven different potash compounds, with normal or untreated rows between the ferti-

[1] See report of agriculturist, p. 145, for details as to fertilizer.

lized ones. Potato scab has been slowly working its way into these plots since the experiment was started a few years ago, although the seed potatoes were treated with the standard corrosive sublimate solution before being planted. Notwithstanding this, potato scab developed quite severely on some plots, and the following table shows to what extent. No stable manure has been applied to these plots, hence that source of contamination has been eliminated.

TABLE IV. — *Showing the Development of Scab on Plots treated with Different Potash Compounds.*

Fertilizer used.	Amount of Scab (Per Cent.).
No potash,	5.0
Kainit,	2.0
High-grade sulfate of potash,	1.0
Low-grade sulfate of potash,	1.2
Muriate of potash,	-
Nitrate of potash,	-
Carbonate of potash,	95.0
Silicate of potash,	3.0

The above estimates of proportion of tubers affected by scab is based upon observations upon the fourth and fifth series of plots. The relative abundance of the disease in other plots was similar, but the proportion of scabby potatoes was larger.

The results given in this table show that there is a marked difference in one instance of the development of potato scab which can be traced directly to the fertilizer employed. It should be noted in this connection that the results in the different plots are very uniform, practically all the potatoes in the carbonate of potash plots showing much scab, and it is quite evident that this fertilizer is favorable for the development of scab. It is also clear that the corrosive sublimate method of treating the seed potatoes, as well as any other similar method of treatment, is of little value when the soil conditions are especially favorable for the scab fungus. The muriate and nitrate of potash plots did not seem to have developed the scab, and undoubtedly much can be accomplished in holding the disease in check by applying fertilizers which

are unfavorable to the growth of the fungus. Wheeler, Hartwell, Sargent and Towar,[1] who have investigated this subject, have shown that acid soils restrict, while lime, ashes, etc., increase, the amount of scab. Dr. Wheeler points out that sulfate of potash, kainit and muriate of potash, in connection with dissolved phosphates, etc., will benefit the soil and render infection less prevalent.

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[1] *Cf.* various articles by H. J. Wheeler, J. D. Towar, B. L. Hartwell and C. L. Sargent, in Bulletin No. 26, 1893, No. 33, 1895, and No. 40, 1896, Rhode Island Experiment Station.

11. Investigations relating to Mosaic Disease.

G. H. CHAPMAN.

The Mosaic Disease of Tomato and Tobacco.

Work on this disease was taken up for the first time at the station in July, 1907; too late in the season to observe the seed beds and the transplanting of field-grown tobacco in its natural state. However, the work of the past year has been more in the nature of verifying the results obtained by other investigators than in research purely, so only a preliminary report can be made at the present time.

The disease occurs on several plants, but seems to be most injurious to tobacco, although it has been found that in the case of greenhouse-grown tomatoes a heavy pruning back will bring on the disease, and, as observed at this station, lessens production.

All investigators agree that the mosaic disease is a purely physiological one, but there seems to be much doubt as to whether it is infectious or contagious in character, or both. There also seems to be some difference in opinion as to the direct cause of the disease. In tomatoes it is always produced when the vines are heavily pruned, and in the work here it has been shown that it is connected in no way with methods of transplanting the young plants, and only results from subsequent pruning.

It has been found that tobacco is much more susceptible under conditions which tend to produce the disease than is the tomato. In the case of tobacco, A. F. Woods[1] found that when a plant was grown in soil containing small roots of diseased plants the disease always occurred sooner or later. In our

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry.

observations on the tomato we have been unable to verify this statement, as in no case has the disease appeared when normal plants were grown in soil which contained roots of plants which had been badly diseased, and in the growing of tomatoes year after year in the station greenhouses there has never been the slightest evidence of infection arising from the soil.

In the case of tomatoes grown under glass the disease did not make its appearance when the plants were left normal, but occurred when the plants were pruned. These conditions held true for soils in which there were diseased roots, as well as for those in which tomatoes had not previously been grown.

In the coming year the work will be renewed, and the disease studied under field conditions in the case of tobacco, and experiments carried on to determine the possibility of its occurrence in the seed bed and also after being transplanted from the seed bed to the field. It is thought that the conditions under which the transplanting takes place may account for the presence of this disease in some cases. One case, at least, has come to our notice which seems to indicate that the disease may result from improper handling. In the particular case referred to, two lots of plants were taken from the same seed bed. One lot was well moistened before being removed, and the second lot was removed in a dry condition. The same machine planted both lots, and it was reported that at least 70 per cent. of the plants removed from the seed bed in the drier state became more or less diseased, while of those properly removed and carefully handled only two or three plants became affected. It has also been frequently observed, in connection with the transplanting of aster seedlings from the same bed under identical conditions, that one lot will show the "yellows" badly, and another lot scarcely at all when transplanted into different localities.

In connection with the field work, experiments of a more technical character will be carried on in the laboratory, with a view to ascertaining the effects which different enzymes (oxidase, peroxidase, catalase, etc.) found in growing plants have upon the production of the disease. Woods[1] infers that oxidase and

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

peroxidase play an important rôle in the development of this disease; but in the work so far carried on in the laboratory at this station it seems more probable that catalase has more to do with the production of a diseased condition. This bears out Loew's[1] hypothesis to a great extent, as in the preliminary work here it has been found that catalase is present in far greater quantity in healthy plants than in diseased plants. However, this point cannot be considered proved, as enough work has not yet been done to warrant such a statement. The results so far obtained will be found in this report.

Description of Mosaic Disease on Tomato.

The appearance of this disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some difference is found in its appearance in extreme cases on the tomato, as will be noted from the following description: —

In the first stages of the disease the leaf presents a mottled appearance, being divided into larger or smaller areas of light and dark-green patches. At this point, however, no swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly, while the light-green areas do not grow so rapidly, and leaf distortion is brought about. In the tomato the light-green areas become yellowish as the disease progresses, and in badly affected plants become finally a purplish-red color. This purplish coloration is found principally on plants which are exposed to strong light, but does not always occur, as it has been found that sometimes, even in badly infested plants, the disease may reach its maximum without showing any reddish coloration whatsoever. The reddish appearance is noticeable only on the upper surface of the leaf, and appears to extend only through the palisade cells. As yet no investigation has been made with reference to its character, but from its appearance under the microscope it is thought that it may be due to the breaking down of the chlorophyll granules, as a result of the diseased condition of the leaf.

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[1] Catalase, Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology, United States Department of Agriculture.

Under all conditions of disease, however, the leaves are much distorted and *stiff*, and often very badly curled, never possessing the flexibility of healthy, normal leaves.

The Growing of Plants used in Experiments.

As the mosaic disease seldom if ever occurs on field-grown tomatoes, and as these experiments were carried on in the greenhouse, a standard greenhouse variety of tomato, the Lorillard, was used in the work. This variety is of medium size, and possesses strong growing qualities.

The seed used was carefully selected and of uniform size, all being over 2.5 millimeters in diameter. The seed was first planted in drills in a seed plot in which no tomatoes had previously been grown, and which could in no way contain any roots, decayed or otherwise, of diseased plants. After the seedlings had reached a height of 4-6 centimeters they were transplanted to 4-inch pots, and then once more transplanted, when they had reached a height of 15-18 centimeters, to the boxes containing the coal ashes, mention of which will be made later, and to the benches into soil which had not previously produced tomatoes.

The plants transplanted to the boxes were used to ascertain the action of excess of various plant fertilizers on the production or intensifying of the disease after it had once been contracted. The plants transplanted to the benches were used for inoculation and various other minor experiments.

Action of Excess of Fertilizers on the Production or Intensifying of Mosaic Disease.

To test the action of excesses of various fertilizers on the pruned and unpruned tomato plants, a fertilizer containing all the necessary plant food for tomatoes was used. The fertilizing constituents in tomatoes, given in parts per thousand, are as follows:[1] —

	Parts.
Moisture,	940.0
Nitrogen,	1.7
Ash,	–
Potassium oxide,	3.6
Sodium oxide,	–
Calcium oxide,	.3
Magnesium oxide,	.2
Phosphoric acid,	.4

[1] Hatch Experiment Station report, 1902.

A fertilizer of the following composition was used, applied in the indicated amounts per acre: —

	Pounds.
Nitrate of soda,	400
Superphosphate of lime,	1,320
Muriate of potash,	280
Lime,	1,000

In order to be certain that the production or reduction of the mosaic disease was due to the excess of fertilizer which was added in each case, a growing medium was taken which contained little or no plant food. In this case pure anthracite or hard coal ashes, which had been sifted through a one-fourth-inch sand sieve, were used.

Five wooden boxes of the same dimensions (45 by 45 by 30 centimeters) were filled to a depth of 25 centimeters with the ashes; to this was added in each case the requisite amount of the complete fertilizer calculated from the above formula. Box 1 contained the complete fertilizer, and nothing else; to box 2 was added an excess of nitrates equal to that already in the fertilizer; to box 3 was added an excess of potash equal to that already in the fertilizer; to box 4 was added an excess of phosphate equal to that already used; and to box 5 was added an excess of lime equal to that already used, — so that the boxes contained: —

Table showing Contents of Each Box.

Here n represents the normal amount of fertilizer.
N represents the nitrates.
K_2O represents the potash.
P_2O_5 represents the phosphoric acid.
CaO represents the lime.

Number of Box.	Coal Ashes.	N.	K_2O	P_2O_5	CaO
Box 1,	n	n	n	n	n
Box 2,	n	n + N	n	n	n
Box 3,	n	n	n + K	n	n
Box 4,	n	n	n	$n + P_2O_5$	n
Box 5,	n	n	n	n	n + CaO

Two tomatoes were planted in each box, one being pruned and the other not. They were allowed to grow for one week, however, before the first pruning, then one plant in each box

was cut back to a point about 2 centimeters above the first leaves. In from one to two weeks all the pruned plants showed symptoms of the disease on the new growth, and continued to show it throughout the growing season. None of the unpruned plants showed the slightest indication of the mosaic trouble at any period of growth.

There appeared to be no difference in the intensity of the disease in any of the boxes, and when the diseased plants in the boxes were compared with plants of the same age grown in soil and pruned back at the same time, no difference in intensity of the disease could be noticed, so it would appear from this experiment that *excess of plant food* will not produce or intensify the mosaic disease of the tomato, although it has been observed that an excess of nitrogenous fertilizers does intensify the disease in tobacco, as well as that an excess of lime tends to lessen it,[1] and there are characteristics displayed by plants resulting from overfeeding which resemble the mosaic trouble. In our experiments with the disease on tobacco these views have been borne out, and it has also been noted that the tobacco is far more susceptible to those changes which bring about the disease than is the tomato.

Catalase in Tomato Leaves.

Some leaves of a perfectly normal tomato plant were treated to ascertain the presence or absence of the enzyme catalase, which has been so well described by Loew,[2] as it occurs in tobacco. As only green tomato leaves were available, they were taken and ground up in a mortar with fine quartz sand and a little water. After the leaves were in this manner thoroughly disintegrated the mass was covered with a .2 per cent. solution of ammonium carbonate $(NH_4)_2CO_3$, and set aside for three hours in a room the temperature of which was 25° C. After standing for this length of time the mixture was filtered through a coarse filter, and the resultant mixture filtered again through a finer filter paper.

The residue, consisting of pulp and quartz sand, was allowed

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

[2] Catalase. Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology.

to stand for a short time to thoroughly drain, and the filtrate was treated with dilute acetic acid 1 : 4. The filtrate was greenish in color, and when acted upon by the acetic acid a flocculent precipitate was obtained which was also greenish in color, — whether due to impurities or pulp is a question.

A portion of unfiltered juice was also saved for treatment. A diluted solution of commercial hydrogen peroxide (H_2O_2, containing 3 per cent. of pure H_2O_2) was treated with a small amount of the residue obtained from the first filtration. An abundant evolution of oxygen gas resulted, showing that catalase was present, in insoluble form, at least. The insoluble catalase has been called by Loew α catalase. As no other known enzyme will break down hydrogen peroxide (H_2O_2) in this manner, it is safe to say that catalase was present.

The first filtrate was added to a diluted solution of hydrogen peroxide, and a somewhat smaller amount of oxygen relatively was evolved. To the precipitate obtained by the acidification and precipitation brought about by the action of the acetic acid on the second filtrate was also added a diluted solution of hydrogen peroxide, and the amount of oxygen evolved was very small, only traces of the gas being found. As this precipitate contained presumably all the soluble catalase found in the leaf, it was shown that the tomato leaf contained very little soluble catalase. The explanation for the greater amount liberated from the first filtrate is that the filter was so coarse that some of the pulp containing the insoluble form passed through into the filtrate, producing an energetic evolution of oxygen. The soluble form of catalase is known and is described by Loew as β catalase.

In the normal condition the tomato leaf contains a large amount of the insoluble form and only traces of the soluble form.

After finding that catalase was present in the normal tomato leaf, a number of leaves of plants affected with the mosaic disease were treated in a similar manner, to determine whether the presence or absence of this enzyme had anything to do with this disease. The leaves of the diseased plants were treated in exactly the same manner as the leaves of the normal plants, so that there might be no chance for error due to treatment of the leaves.

Some leaves of a plant badly affected with the mosaic disease were treated in the manner previously described. In appearance the pulp and the filtrate were lighter in color than in the case of the normal plants, due probably to the fact that there was less chlorophyll in them than in the normal specimens.

When allowed to react with hydrogen peroxide (H_2O_2) it was found that both forms of catalase α and β were present, as oxygen was evolved from the solutions in sufficient amounts to be measured.

Since it was obvious that both α and β catalase were present in healthy and diseased plants, it was decided to take a weighed amount of healthy and diseased leaves and measure the oxygen evolved in a given time from a solution containing a known percentage of hydrogen peroxide. For this purpose 5 grams of healthy leaves were treated in the manner previously described, and the oxygen given off was carefully measured by an ordinary water displacement method. The soluble catalase was not precipitated, however, but the filtered juice was added in each case directly to the solution of hydrogen peroxide. The strength of solution used was as follows: —

To 120 cubic centimeters of pure distilled water was added 20 cubic centimeters of commercial hydrogen peroxide, making a solution in the proportion of 1 : 6. The pulp containing the insoluble catalase was added to this solution, and the amount of oxygen given off carefully measured. This was done both for healthy and diseased plants. The results obtained for the insoluble or α catalase are given below: —

Table showing Oxygen developed by Catalase in Healthy and Diseased Leaves.

	Time (Minutes).	1.	2.	3.	4.	Average.
		c.c.	c.c.	c.c.	c.c.	c.c.
Healthy leaves, ...	5	90.00	165.70	147.30	87.00	122.50
Diseased leaves, . . .	5	34.75	80.50	65.48	21.60	50.58

From these results it may be safely stated that there is certainly a lack of insoluble catalase in leaves of the tomato which are affected with the mosaic disease.

To a watery solution of hydrogen peroxide of the same proportion as used above, *i.e.*, 1 : 6, was now added the soluble

or β catalase extracted from normal and diseased plants. The results in this case indicated also that the leaves affected with mosaic disease were deficient in soluble catalase. The results obtained are tabulated below: —

Table showing Oxygen developed by β Catalase in Healthy and Diseased Plants.

	Time (Minutes).	1.	2.	3.	Average.
		c.c.	c.c.	c.c.	c.c.
Healthy leaves, ...	50	26.00	48.30	33.10	35.80
Diseased leaves, ...	50	14.40	23.70	27.40	21.80

The foregoing results show plainly that catalase is greatly deficient in both α and β form in leaves affected with the mosaic disease.

As catalase is possessed of the property of decomposing hydrogen peroxide, and as it is a well-established fact that hydrogen peroxide is highly injurious to plant life, and also that it may possibly be formed[1] as an intermediary step in the various metabolic changes in plant growth, it is an interesting problem to discover whether the lack of catalase is a prime factor in the production of the mosaic disease. Work along these lines will be continued, and the results announced in a future report.

12. Some Factors which underlie Susceptibility and Immunity to Disease.

The permanent existence of any species depends upon its capacity for adapting itself to its surroundings. Health and disease in organisms are intimately associated with environment; and heat, light, moisture, plant foods, etc., are important factors. An understanding of the optimum conditions necessary for the growth of a plant is of the greatest importance as regards its normal condition of health. The close student of physiology and pathology must always have in mind the perfect type of plant, that is, one possessing perfect health, otherwise his diagnosis may be of little value, and the cause of

[1] Erlenmeyer, Berichte der deutschen Chemischen Gesellschaft, 1877. (Notes by Loew.)

certain unfavorable symptoms may escape his notice. In the same way that a physician can diagnose a patient's condition by an examination of certain organs, or gain an idea of the state of his general health by considering various symptoms, can one familiar with the normal functions of a plant ascertain its condition by observing certain features which it may display, and then discover the cause of the trouble.

The highest conception of health and vigor in plants is brought to a realization through the remarkable skill of expert gardeners, and it is no exaggeration to say that this class of men possess the most profound knowledge of a plant's requirements and limitations. Those trained men who have made a specialty of greenhouse crops for years are unexcelled in their skill and knowledge of the plant's needs, and this is also true of many intensive agriculturists. Some of these specialists have gained remarkable insight into the nature of plant reactions, the slightest change which takes place in the plant organism being noticeable to them; but such a large percentage of this knowledge is intuitive or instinctive, as it were, that it cannot be conveyed to others. The best gardeners are in sympathy with all that pertains to the well-being of their plants, and they are continually observing each minute change which the plant may undergo, thus gaining a knowledge of the influence of the external factors which in any way affect the organism. A slight modification in the light intensity or in the temperature for even a brief period is sufficient to cause variations in the plant development which are discernible to the expert gardener. The conditions which both directly and indirectly affect a plant in respect to susceptibility to disease are various. A plant, both in its chemical and physical characteristics, is affected by light, heat, electricity, gravity and soil, moisture, air, biological relationships, etc., and in greenhouses by such factors as ventilation, air space, quality of glass, and in fact the simplest features connected with greenhouse construction. It is in a greenhouse that we gain the most insight into the relationship existing between the condition surrounding plants and their susceptibility to disease, for here the gardener has the environment largely under his control, and can therefore regulate the conditions to meet the requirements of

his plants. The relation of external factors to plant diseases can be most satisfactorily studied in the greenhouse, because it is possible to modify and eliminate those which have a direct bearing upon disease, and in this way their true significance may be determined. When the conditions surrounding the plant are far from the optimum, injury and even death may follow. A stimulus which may prove beneficial under certain conditions may injure or cause the death of the organism under others; and it is only by possessing a knowledge of the optimum conditions for stimulation and by meeting the normal requirements of the plant that we can expect to obtain a perfect organism. Everything which has a bearing upon the development of the plant must be carefully considered if the perfect type is to be realized. These factors not only affect development, but have a fundamental bearing upon immunity; and if the environment can be controlled, disease can be controlled to a large extent. Even when it is not possible to modify the heat, light and moisture, as is the case out of doors, infection can be largely eliminated by making use of certain cultural practices; in fact, cultivation constitutes one of the most important factors in the control of disease.

Light affords a good illustration of the rôle a single factor may play in the configuration of plants. The physiological effect of light is to inhibit growth and to induce the formation of a firm texture of the tissue, On the other hand, lack of light stimulates growth, but plants grown in darkness are etiolated and lack firmness of tissue. There are many instances of the absence of light being responsible for serious troubles, and in others light undoubtedly exerts a detrimental influence. The tonic influence of the Bordeaux mixture in favoring the formation of chlorophyll and carbon assimilation in many plants would appear to be due to the screening or lessening of the light intensity. Sun scald, which occurs on various trees, is brought about by excessive light, as in the case with apple trees, which, when defoliated by the gypsy moth, usually die from the effects of sun scald. On the other hand, shading often causes sun scald by preventing the ripening of the wood.

There are apparently some cases, at least in greenhouses, of too intense light, or the conditions resulting from it, causing

trouble to crops. In the northern latitudes many greenhouse crops do not obtain sufficient light during the winter months, and when cloudiness prevails it is with some difficulty that crops are matured without becoming diseased. All expert greenhouse men mature their crops when the weather conditions will permit, and not according to the calendar; in other words, it requires a certain definite amount of light, or so many light units, as it were, to mature a crop. The light in May, for example, is equal in intensity and amount to about twice that of corresponding periods of a day in November; consequently, it requires about twice as much time to bring a crop to the same degree of maturity in November as it would in May.

Lack of light is responsible for various mildews and leaf spots, top-burn or tip-burn, wilts, etc. Many of these leaf spots are seldom if ever found on plants to which sunlight has access. The Sclerotinia diseases of lettuce, water cress and parsley are likewise induced by crowding and shading, and light in such cases will prevent infection by the formation of resistant tissues. It is well known that absence of light causes the so-called "layering" of wheat and "damping off" of cuttings, and the mildews of various plants grown in the shade are too well known to need consideration,

The improper regulation of atmospheric moisture and ventilation is responsible for many fungous diseases, and the control of these factors is important in preventing the troubles. Among the mildews, Cladosporium can be entirely controlled by holding the moisture in the greenhouse in check, and by paying strict attention to proper ventilation and to normal light conditions. Many gardeners have succeeded in controlling the chrysanthemum rust by using proper precautions in regard to moisture.

A series of the most troublesome diseases common to cucumbers and melons out of doors — Plasmopara, Alternaria and Anthracnose — can be absolutely controlled in the greenhouse by paying attention to moisture, light and ventilation. The circulation of air, as well as light, has a marked effect upon the development of resistant tissues in greenhouse crops, and the control of moisture is necessary to prevent the germination of

various spores which are likely to infect crops. It is well known that the tops of trees are less likely to become infected by fungi, owing to the smaller amount of moisture there than about the branches nearer the ground; and asparagus plants when grown under trees or covers which protect them from the dew seldom show any indications of rust.

Too great a degree of heat and moisture in the soil gives rise to serious troubles, as may be seen in the case of Œdema of tomatoes; and when seedlings are grown in soil that is kept too moist and at too high a temperature, they are likely to "damp off." The presence of water in a plant in excess of certain amounts is favorable to disease, as is shown in the carnation's susceptibility to rust; for example, those carnation plants possessing the greatest amount of water in their tissues appear to be the most susceptible to rust. The stimulating effects of electricity, fertilizer and sterilized soil often prove injurious by developing too high a water content in the tissues, thus rendering them more susceptible to disease. Tillage, manuring, irrigation, mulching, etc., are important factors in securing vigorous plants, and go a long way towards rendering them immune to certain diseases. An excessive amount of moisture in the soil stimulates growth and often renders plants more susceptible to fungous diseases, and a lack of water has the same effect; in fact, stimulation of various sorts may result in weakening a plant and rendering it less immune to disease.

The life history of an organism presents different stages of susceptibility or immunity to disease, corresponding to different stages of development; for example, young plants may be more susceptible to certain diseases than older ones. Very young seedlings often fall a prey to the "damping off" fungus, but when they have reached a certain stage of development they become immune to fungi, and the younger and less-developed parts of mature plants are more susceptible than the older parts. Vegetative rest and overmaturity are also favorable to disease, while the conditions associated with isolation are unfavorable for infection. Weakened plants are more susceptible to disease than strong ones, and in most cases, if not all, vital depressions are the real causes of disease. Vital depressions are brought about by the abnormal conditions which modify and

reduce the power of resistance, consequently the organism falls a prey to the ever-present germ.

The causes underlying susceptibility are much better understood than those of immunity. Why it is that the moment a plant becomes weakened various organisms attack it, is not fully understood. We have observed many instances of certain treatments weakening plants, and as a result it is surprising to note the number of organisms which always attack the plant a very short time afterwards. The changes which actually take place in an organism in a depressed condition are not known, but many of these may be of an abnormal chemical nature. It is possible that these abnormal chemical changes stimulate organisms to attack weakened plants; that is, the loss of immunity increases the susceptibility of the organism to disease, due to vital depressions in the plant, which may result in the giving off of substances that act as a stimulus and attraction to invading organisms. Briefly stated, susceptibility to disease may be associated with chemotactic irritability.

Some crops are probably rendered more susceptible to fungous diseases by cultivation. The limitations of forcing have undoubtedly been overstepped in some cases, and this is especially true of the carnation, which has been much troubled with the wet and dry stem rots since the modern methods of forcing have come into vogue.

In the case of outdoor crops, great differences exist in the environment, due to climatic influences. The conditions may be such that a disease constantly causes loss in one locality and scarcely any in another; and, while it may be necessary to spray for a trouble in one State, in others no attention need be given it. No doubt in some instances it would be wiser to devote one's energies to cultivation, as a means of preventing plant diseases, than to resort to the use of fungicides. Our most skilled agriculturists, such as florists and market gardeners, seldom if ever resort to spraying, and in greenhouse culture the use of fungicides is practically unknown. Certain crops are greatly benefited by being sprayed with fungicides; but, on the other hand, there are crops which have been sprayed for many years with little or no benefit as far as the control of pathogenic fungi is concerned, and the money spent

for spraying would in such instances be more wisely used in methods of cultivation. Some of our best landscape gardeners have advocated that, if $25 were to be used in planting a tree, about $23.50 of it should be used for preparation; and such advice is based upon the best agricultural practices. If intensive agricultural methods were applied more often to the growing of plants, pathologists would have much less diagnosing of diseases to do.

Every influence which may in any way affect plants should be carefully studied. We should understand what influence the chemical, physical and biological properties of soil, manures, fertilizers, air drainage, etc., have upon susceptibility to disease. The plant organism is an extremely complex mechanism, very plastic and responsive, and is continually being acted upon by a number of forces or stimuli which in turn produce a series of self-regulatory and correlative reactions. Undoubtedly in the future the control of plant diseases will depend more upon breeding and cultural conditions than now; but for the present, spraying must be employed when practicable for the control of diseases until something better shall have been discovered.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

Outline of Work.

The four divisions into which the entomological work of the experiment station is naturally divided — correspondence, experimental investigations, special research and publication — have each received their share of attention during the past year.

The correspondence has been as large in amount as heretofore. Many inquiries about many kinds of insects have been received and answered as fully as possible: and in this connection the printing of a number of circulars, treating of the insects most frequently asked about, has greatly facilitated the work, as a circular can be sent in a small fraction of the time necessary to write out the same information, besides giving an opportunity to send illustrations of the insects and of their work.

Experimental investigations during the year have been along numerous lines. Determinations of the resistance of different crops to fumigation with hydrocyanic acid gas have been continued, and are now complete for the cucumber, and similar tests for muskmelons are under way.

An extensive series of tests of different methods for the control of cabbage, turnip and onion maggots was also begun. The cabbages, being the first crop on which treatment was possible, were experimented with in nine different ways. Unfortunately, it soon became evident that no treatment of any kind would be needed, almost no maggots being present either in the check rows or in the field anywhere, so that the only data of any value which could be obtained were those relative

to the cost of different materials and the ease with which they were applied, leaving the question of their relative efficiency for subsequent determination in other seasons.

Observations on the dates of appearance of the oyster-shell, scurfy and white pine scales have been made as usual, and should be continued for a number of years, to obtain reliable averages for use in spraying. Observations on the number of broods of the codling moth have also been continued, and a more extensive series of experiments with this pest is now being planned for next season.

In 1906 the "blight" caused a large monetary loss in the Connecticut River valley on the onion crop, and as this is caused by a thrips, studies of the best methods of controlling this pest were undertaken in co-operation with several large onion growers. The main difficulty in this work seems to be to devise a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. This problem is now being worked upon, and with good prospects of success.

The number of new mixtures produced for use against the San José scale has necessitated many tests of these materials, some of which seem quite effective, though expensive, while others apparently are of no value. Thus far nothing tested at this station which is reasonable in cost has excelled the lime and sulfur wash, though a few trials of one substance are quite promising, and these will be continued during the spring of 1908.

Investigations on the work of cranberry insects and the best methods for controlling them have been continued in charge of a special investigator located at Wareham, and it is hoped to publish the results of this work soon as a bulletin. At the request of the Cranberry Growers' Association, sets of cranberry insects and samples of their work are being prepared, to be placed in different parts of the cranberry-growing region, where they will be most easily accessible for examination by growers.

During the summer the life history of the oriental moth was carefully studied, and all stages of its existence were described and photographed. In addition, a study was made of the local

conditions where it occurs, and it was found that the limits of its distribution, as already published, though approximately correct, are not entirely so, the insect having been found in one or two directions beyond those limits. In most of the infested territory the brown-tail moth is abundant, and spraying with arsenate of lead was very general in that region last summer. The result was also to destroy large numbers of the larvæ of the oriental moth, the treatment being so effective that in August it was hard to find any of the caterpillars without making a prolonged search.

These facts indicate that this insect is not likely to become a serious pest. If it should become well established, however, in some locality where no attention is paid to insect pests, it is possible that it might cause considerable injury; but in such a case it is probable that a single thorough treatment there would be effective for several years. The Japanese name "ira-mushi," for this insect means "the nettle insect," and during the summer several reports of the nettling caused by the spines of the caterpillars were received, indicating that, if this insect should at any time become very abundant in an inhabited locality, the residents there might suffer some inconvenience from its presence.

Massachusetts is close to the northern limit of the distribution of some insect pests and near the southern limit of others. It seems probable that for some of these there are portions of the State where these pests may be of importance, while in others they will require no attention. It is important that the exact facts in this regard should be determined, and researches have been begun to ascertain the localities in which comparative immunity from certain pests may be expected. To obtain definite results on this subject will be the work of several years and much correspondence, but it is hoped that when they are obtained, directions can be prepared which will guide towns in different localities in making their annual appropriations for the protection of their trees, which will save many thousands of dollars.

Three bulletins on insects (Nos. 114, 115 and 116) have been published during the year, besides numerous circulars already referred to, these last being used only in answering

correspondence. In addition, a number of other articles too brief for bulletin material or not adapted for a publication of this nature have appeared elsewhere, and several more are nearly ready for the printer.

Insects of the Year.

The year 1907 has brought many inquiries about different insects. As heretofore, however, the San José scale has been most prominent in the correspondence, followed closely by the oyster-shell scale, plant lice, — particularly the woolly apple louse, — the codling moth, the plum curculio as an apple pest, the elm-leaf beetle and the apple maggot or railroad worm.

The elm-leaf beetle, after several years of comparative unimportance, is again becoming a serious pest. In 1900 and 1901 it caused much injury in the Connecticut valley and in eastern Massachusetts, and in 1902 its work was also very noticeable. In the spring of 1903 the beetles were abundant, large numbers of egg clusters were found, and there was every promise of another year of serious injury. During May and June, however, there was a drought so marked that grass dried in the fields and the leaves of the elms became hard and tough and many fell off. It was noticed that many of the egg clusters of the elm-leaf beetle failed to hatch under these conditions, and that the young larvæ in many other cases seemed unable to bite into the tough, dry leaves, so that the work of this insect in 1903 was unimportant. The following winter was unusually severe, but whether this was also a factor in the result cannot be stated. Whatever the cause, however, few elm-leaf beetles were present in 1904, 1905 and 1906, though in the year last named they were increasing in abundance; but last summer (1907) they had become quite plentiful, at least in certain localities, and it is probable that they will be as injurious as formerly in a year or two, unless climatic factors again cause their destruction.

Just how far the drought of 1903 was responsible for the destruction of these insects it is of course impossible to say; but the abundance of unhatched egg clusters and the evident struggles of the tiny grubs to break through the unusually toughened epidermis of the leaves during that period are very suggestive.

The appearance of the leopard moth (*Zeuzera pyrina*) in and around Boston during the past year adds another important insect to the list of pests with which Massachusetts must deal. This insect has been quite abundant around New York City for some years, but has not been reported from this State. As a borer in shade trees it is a serious pest, and its presence must hereafter be taken into consideration by our city foresters and tree wardens.

The brown-tail moth has continued to spread over the State, but in those localities where it has been longest present it seems to be becoming less serious and more generally attacked by disease. Whether this condition will be permanent or is only temporary cannot be determined now, but its permanency is greatly to be desired.

The presence of the San José scale in the Housatonic valley has been suspected for several years, simply because there seemed to be no reason why it should not be present there. Specimens of this scale from several localities in this region, received during the past season, demonstrate its presence there, leaving only the higher parts of the Berkshire hills and the northwestern corner of the State as localities from which it has not as yet been reported, and time will probably add these portions of the State to the list of infested regions.

The marked decrease in abundance of root maggots and cut worms this year should be noted, while the spruce gall louse, squash bug and several kinds of caterpillars, all common pests, appear to have been unusually abundant; but on the whole the year has been without a serious insect outbreak of any kind.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

Outline of Work.

The work in the veterinary department of the station naturally falls under one of the following divisions: correspondence, examination of specimens, and original investigations. These merge so much one with the other that they are by no means as distinct as the divisions would seem to indicate. It not infrequently happens that through correspondence attention is called to the existence of a peculiar disease among farm animals. Specimens are asked for, and forwarded for examination, which sometimes afford material for original investigations.

Correspondence.

During the past year letters have come to hand from people in every part of the State, asking for information regarding the sickness of individual animals, or perhaps regarding a disease that has appeared in a herd or flock, affecting many animals. Of necessity it is impossible to make a correct diagnosis in every such instance, from the description of the case as detailed by the correspondent. In other instances the symptoms are so accurately given and of such a character as to enable one to diagnose the case with certainty, and advise a specific course of treatment. The correspondence work carried on with those living in rural sections, where no qualified veterinarian is accessible, has proven of such benefit to the farmers as to warrant its continuance, notwithstanding the difficulties that are encountered in arriving at definite conclusions as to diagnosis and treatment. When it is impossible to give definite directions for the treatment of an individual animal, it is

possible from the symptoms enumerated to recommend a line of treatment, or general directions can be given which when carried out make it possible for the stock owner to pursue such a course as to prevent the spread of the disease to other animals exposed, or to prevent its recurrence.

Examination of Specimens and Original Investigations.

For many years it has been the practice of the veterinarian of the college to examine material from sick or dead animals, and to report the findings to the one sending the specimen, and advise a line of treatment for the individual animal or protection of the remaining animals of the flock or herd.

From an examination of such specimens as have been sent in during the past year, a diagnosis has been made of nodular disease of sheep, caused by the parasite œsophagostoma Columbianum, enterohepatitis of turkeys, verminous bronchitis of sheep, fowl cholera, swine plague and other more common diseases of a less serious nature. Through correspondence and the sending of specimens a very interesting and quite uncommon disease of poultry in this country was brought to the attention of the department.

In January of the present year there arrived at the department by express a dead fowl, which upon post-mortem examination exhibited some of the lesions of European fowl cholera. Microscopic examination gave support to that diagnosis. To confirm the same, a pigeon was inoculated with a small quantity of blood from the heart of the dead fowl. After the lapse of about twelve hours the inoculated pigeon was found dead. A microscopic examination, together with culture tests, demonstrated the presence of the fowl cholera organism in the blood. Subsequent inoculations and examinations gave similar results.

Considering the seriousness of the disease, its rare occurrence in this State, together with the possibilities of its rapid distribution among flocks of poultry, through sale of birds and otherwise, a visit was made to the farm from which the specimen had come.

It was found that about two hundred birds were kept by the poultryman, in two different flocks situated some fifty feet apart. About one-half of the fowls had been raised upon the

farm the previous summer. The remainder of the flock, consisting of fowls and chicks, had been purchased of a dealer in live poultry the previous November. At this time all the birds raised and purchased seemed to be in perfect health. The history of the outbreak is briefly as follows: —

About Jan. 1, 1907, one morning the poultryman found, upon going into the house containing the purchased stock, a dead bird upon the dropping board. No sick fowls had been noticed the day previous. During the next two weeks several dead birds were found under conditions similar to the first. Few or no fowls of the flock exhibited symptoms of sickness at any time during the existence of the trouble. The loss continued, however, up to the middle of January, when the specimen was sent to the station. The total loss amounted to about twenty per cent. of the entire flock. One morning three dead birds were found under the roosts. At no time did the disease appear among the fowls raised upon the farm. This is probably to be accounted for by the fact that the infectious material was brought on to the place by the purchased stock, and that the two flocks were kept entirely separate. As soon as a diagnosis of the disease had been made, the poultryman was advised of the contagiousness and seriousness of it, and the possibilities of its spreading to other flocks in the neighborhood. He showed a willingness to do all in his power to eradicate the disease as soon as possible. At an early date all the remaining birds in the infected house were destroyed, the house thoroughly cleaned, fumigated and sprayed with a disinfectant solution. The treatment was so heroic and so faithfully carried out that there has been, so far as known, no recurrence of the trouble.

On April 18, 1907, a dead fowl from a farm on the opposite side of the street to the one where fowl cholera had existed was sent to the station.

An autopsy, supplemented by inoculation experiments and microscopic examinations, resulted in a diagnosis of fowl cholera, identical in every respect with that found to exist in the fowls kept on the adjoining farm. There were from four to five hundred birds on the place. A part had been raised on the farm, a part purchased of itinerant dealers in live poultry. The fowls were divided into two lots. About one hundred had

the run of a large, dry, open barn cellar; the remainder were kept in a single long poultry house, divided into sections with partitions of wire netting. Both lots were allowed free range, all mingling together in one flock during the day.

It was learned from the owner on April 27 that the two weeks preceding the date of sending the dead fowls to the station (April 18), between fifty and sixty fowls, a part from each flock, had died very suddenly. It was also learned that during the winter of 1906 about one hundred and twenty-five birds had died from flocks kept in the poultry house and barn cellar during that winter. No cause was found to account for this large mortality. Taking into account the history of the case and the symptoms exhibited by the birds as given by the owner, it seems probable that the loss in 1906 was also due to fowl cholera. There is no positive proof that this was the case.

It was reported by the owner of the flock in question that his birds frequently came in contact with fowls kept on the opposite side of the street, and that individuals from both flocks ranged over the same ground.

In dealing with the last and larger flock, circumstances did not seem to warrant the application of the line of drastic treatment that had been carried out with the flock dealt with earlier in the year. Deaths had occurred among fowls kept in the poultry house and in the barn cellar; all had run together, when the weather permitted their being outside the buildings, and it seemed certain that the infection had become widely spread about all parts of the farm in the immediate vicinity of the buildings.

To arrest the spread of the disease, the owner was advised to thoroughly clean all parts of the buildings with which the fowls had come in contact, including a removal of the surface soil from the barn cellar and pens in the poultry house. He was further advised to follow this cleaning with a liberal application of a coal tar disinfectant and a fresh lime whitewash. As a further precaution against the spread of the infection through the medium of food and water contaminated with infectious fecal matter, specially constructed automatic feed boxes and drinking fountains were recommended. In addition, it was

suggested that from five to ten grains of permanganate of potash be added to each gallon of drinking water, the water to be supplied fresh twice daily, and kept as free as possible from organic matter, which destroys the antiseptic properties of the potash salt. These measures, supplemented by frequent cleaning of houses, disinfection of fæces, etc., seem to have completely stamped out the disease, as nothing has been learned of its recurrence.

Judging from the reports that have been made of the few previous outbreaks of fowl cholera that have occurred in this country, it would seem that the two in question have been of a mild type, for in each outbreak previously reported the spread of the disease has been much more rapid and the mortality greater, amounting in some instances to one hundred per cent., as is frequently the case with the outbreaks in Europe. The successful treatment adopted in dealing with the second case, which consisted of mild measures, also tend to show that the disease was not of that virulent nature frequently met with.

Considering the few outbreaks of fowl cholera that have occurred in this country, and the benefit to be gained from knowing the source of the infection in combating this disease, it is to be regretted that the source of the contagion in the cases under consideration could not have been determined. It seems fair to conclude that it must have been introduced on one of the farms through some of the fowls purchased of the traveling dealers in live poultry.

Another interesting and, so far as can be determined, new disease for poultry was brought to the attention of the department through a communication from a poultryman on the Cape in the summer of 1906. An investigation of the disease was begun on June 27 of that year and concluded in October of the present year. During this time a series of experiments have been carried on at the college in conjunction with those conducted at the farm.

The part of the farm given up to poultry culture consisted in the main of a sand plain. A portion on which the chicks were kept consisted of pure white quartz sand, and was devoid of vegetation except for an occasional weed growing upon it. This locality had many years previously been the site of salt works.

The present owner had built upon this location a poultry plant with a capacity sufficient to handle from fifteen hundred to two thousand birds. This plant consisted of poultry houses, incubator cellar, brooder houses, coops, etc. Everything about the place, including equipment, was of the latest pattern and of modern construction. The practice was to hatch chickens in incubators and brood them under hens and in brooders. The hens with chicks were kept in coops placed some distance apart in yards. Several small yards were fenced off with wire netting, each of which contained a brooder of sufficient size to accommodate from fifty to seventy-five chicks. The disease never made its appearance among any of the adult fowls or any of the young chicks except those brooded in brooders. Those kept with hens in individual coops never contracted the trouble. The mortality among the brooder chicks usually ranged from ninety to one hundred per cent. The loss of from three to five hundred in a season was not an uncommon occurrence. It was extremely rare that a chick once attacked ever recovered. In some lots a few escaped contracting the disease, while others of the same lot succumbed to it. It usually attacked chicks at the age of three weeks, although those older or younger than this were not exempt.

The first appearance of the trouble was characterized by the development of large serous or water blisters on the front and upper parts of the featherless portions of the legs and feet. After a period of twenty-four to forty-eight hours the blisters would rupture and the serum escape. Frequently the affected parts would be rubbed with the head, and as a result the featherless parts of the head would become affected in a similar manner to the feet and legs. An extension of the disease about the head invariably led to an affection of the eyelids, which would become fastened together by the sticky exudate. The ball of the eye was not involved. In some instances the head would first become affected, later the feet and legs. Occasionally it was found that the head or the feet alone would be the only part involved. So far as known, the posterior part of the leg or parts of the body covered with feathers never became affected. After rupture of the blisters and escape of their contents the surface skin became dry and shriveled, after a time

becoming detached, leaving behind the moist underlying vascular tissues. These soon become covered with soil and encrustations of tissue and serum. Forced removal of these crusts was followed by capillary hemorrhage and the formation of new crusts. A shedding of the crusts frequently occurred as the disease advanced. As a final result, all parts of the soft tissue of the feet were destroyed or modified to such an extent that the toes became bent upward, and the foot deformed so that only the ball of the foot would come in contact with the ground when walking was attempted. In addition to the local lesions, there were symptons indicating a considerable degree of constitutional disturbance. Nutrition seemed at a standstill. Growth was arrested, although there was a disposition to eat and drink. The closing of the eyelids often made it impossible for the chicks to take food or water, even though they were disposed to do so. When the lids were separated the birds usually ate and drank ravenously until they became filled.

Numerous remedies had been employed for the treatment and prevention of the trouble, but to no avail. The disease made its appearance in each lot of chicks shortly after they were placed in the brooders.

It was the opinion of the poultryman that the soil contained some poisonous irritating substance that was accountable for the trouble. Why it should appear in brooder chicks and not among those brooded under hens he was not able to explain. To settle this matter a sample of soil was submitted to chemical analysis, but nothing of an irritating or poisonous nature was found.

The general course and character of the disease seemed to indicate that it was the result of the local action of something. It was suspected that it might be due to the heat from exposure to direct sunlight. Experiments were made upon chicks by the use of a lens to concentrate the sun's rays upon the legs and feet, and it was found possible to produce upon experimental chicks lesions identical with those found upon chicks brought from the yards, even to the extent of producing a slight deformity of the toes, due to the contraction of the tendons and the cicatricial tissue. An attempt was made to rear feathered-legged varieties of chicks upon the same ground where there

had been the greatest mortality, but owing to some mishap in connection with the incubation of the eggs, the work along this line was not completed. It is hoped to carry out this detail at a later date.

As a practical remedy for the trouble this poultryman has had to contend with, it was suggested that all chicks be removed to and raised upon an adjoining piece of ground sufficiently fertile to support vegetation, that would protect the featherless and tender portions of the body from the heat of the sun.

During the past summer this suggestion has been complied with, with the result, to quote the owner's own words, under date of Oct. 4, 1907: "That so far this season I have not had a single case of sore head or feet, such as you know of, among my chicks."

At present a series of experiments is being carried on to determine the effect of poisons, used in tree-spraying work, upon animals consuming forage grown beneath the trees.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

In meteorology, where the work is in a large degree essentially that of observation and tabulation, the records must be continued from year to year without material change, if the results are to be of value for the purposes of comparison. As the length of time covered by the records increases, the data become more valuable, and the mean climatological conditions can be determined with constantly increasing accuracy.

During the past year the work of this division has been a continuation of that of previous years, and no material modification has been made. Although efforts are constantly made to increase the precision of the records, the general form and range remain unchanged.

The semi-daily observations, at 8 A.M. and 8 P.M., have been taken regularly, and the results transcribed in the permanent record book. Many records from the self-registering instruments have also been entered, to keep them compact and accessible. The usual monthly bulletins, giving much of these data, have been printed on the first of each month. These are now mailed from the director's office instead of from the printing office as heretofore, which involves a little loss in promptness of distribution. The December bulletin will contain a summary for the year, instead of the usual remarks.

The local forecasts have been received by telegraph from the section director of the United States Weather Bureau, at Boston, and the signals displayed from the flagstaff on the tower. This division has co-operated with the section director in furnishing the usual voluntary observer's reports for each month, and the snow reports during the winter season. The

horticultural division has consented to keep a phenological record during the growing season for the use of this division, and a copy is furnished the section director at Boston.

The old thermometer shelter on the campus has been replaced by a larger and more convenient one, and an underground lead-covered cable placed for the purpose of providing an electric light in the shelter. A second underground cable is in place for connecting the tipping-bucket rain gauge with the recording instrument in the tower. A specially designed cover for the man-hole of the heating system, which is near the rain gauge, has been secured. It is proposed to place the rain gauge on this cover in such a manner that the heat from the man-hole will melt the snow which falls in the gauge, and thus furnish a precise record of the time of the beginning and ending of snowstorms.

A maximum thermometer of standard pattern is the only addition to the instruments made during the year.

No change in the personnel of the observers has been made during the year.